Materials in Design Engineering

FORMERLY
MATERIALS
& METHODS

SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES

September, 1957

Synthetic Rubbers—Manual No. 141

Strong Aluminum Castings

New Nickel Alloys for High Temperatures

Where to Use Polyester Film

Mechanical Finishes for Stainless Steel

Designing with Magnet Materials

Complete Contents—page 1

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Materials
in Design Engineering® *formerly Materials & Methods*

Selection & use of metals, nonmetallics, forms, finishes

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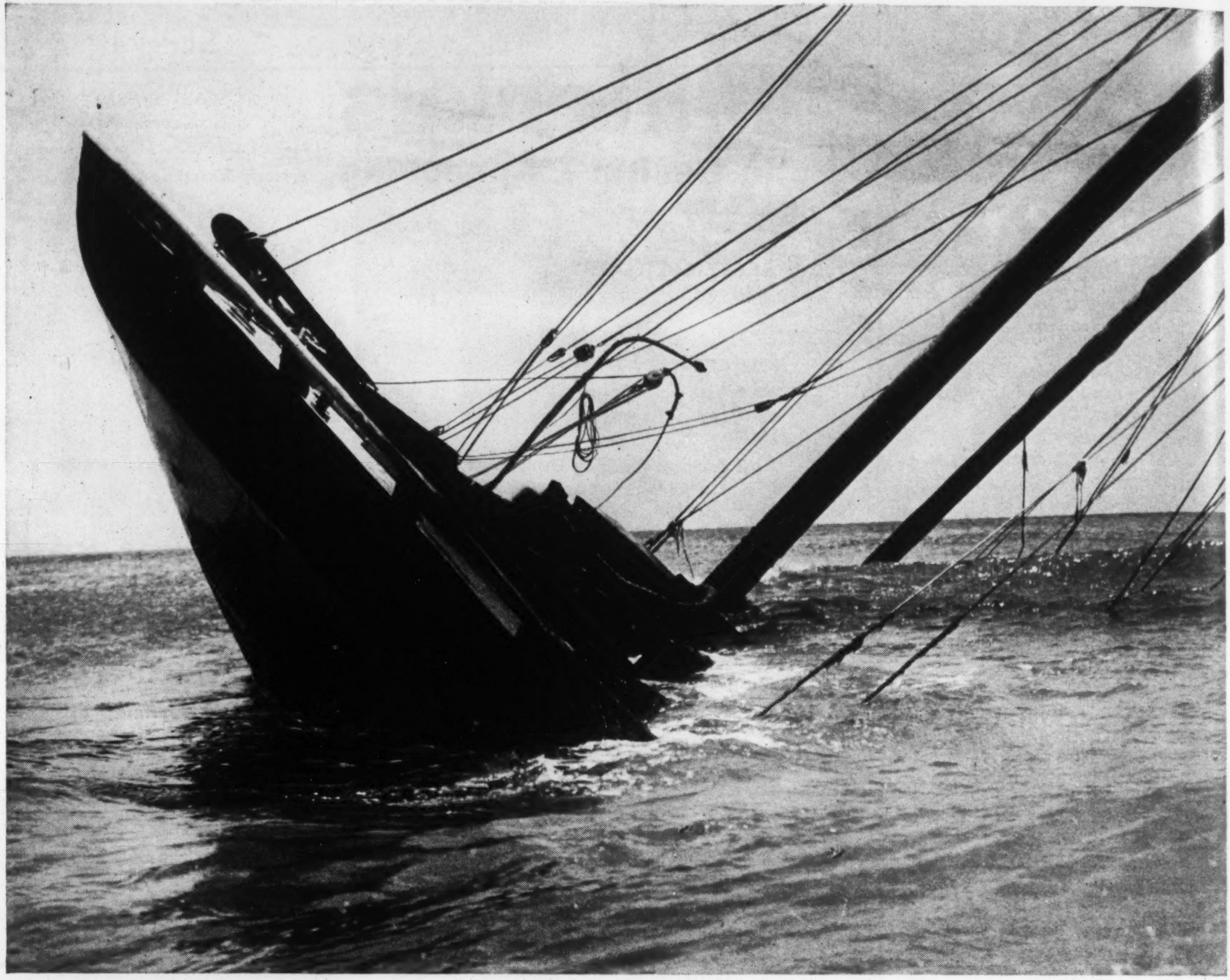

A timely warning from nickel might have made a difference

The sea seldom offers a clue to what lurks beneath its surface. But man can find out.

He beams sound waves to the ocean floor. And listens as they come bouncing back. The technique is called "echo sounding." It's the modern way to probe the depths . . . to map sea-bottom contour . . . to locate schools of fish . . to avoid reefs and other underwater obstructions.

One of the principal types of instruments (the fathometer) used in echo sounding depends on nickel for sending and receiving the telltale waves. Nickel, you see, has a rather unusual physical property called *magnetostriction* . . .

This simply means that it changes dimensions when exposed to a magnetic field. And it can be made to contract and return to its original dimensions rapidly enough to generate powerful sound waves.

Of course, nickel has other useful properties. Strength and toughness, for example. Resistance to corrosion. Electrical conductivity. But *magnetostriction* is the vital one here. And nickel is about the only readily available metal that offers so much of it.

Do you have a metal problem? Corrosion? Wear? High Temperature? Then send for Inco's handy 16-page booklet: "Standard Alloys for Special Problems." It's your guide to more than 20 alloys developed specifically to give longer, better service under destructive conditions.

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What's new IN MATERIALS

...AT A GLANCE

A HEAT TREATED TITANIUM ALLOY is said to have a guaranteed tensile strength of 170,000 psi. The alloy is presently being used in such aircraft applications as bomb ejector cylinder and piston parts, and jet engine vanes and hubs. According to the producer, the heat treated alloy cannot be welded. (More details next month.)

ALUMINUM FOAM can be sawed, nailed, cemented, screwed and bolted like wood, and may someday replace wood in a number of applications. Gas bubbles, formed in molten aluminum, honeycomb the metal with air cells upon cooling and produce a lightweight, fairly strong material. At present, the aluminum foam is difficult to cast, weld and forge.

ACETATE TREATED COTTON FIBERS have better heat, rot and abrasion resistance than untreated cotton. One drawback is price—nearly twice that of untreated cotton. The treated fibers are not yet commercially available.

A NEW FLEXIBLE CORK GASKET MATERIAL is said to effectively support a wide range of loads with adequate cushioning. The material, consisting of minute cork particles combined with a binder, is said to insulate against heat and cold and is resistant to water and mold growth. (More details next month.)

A HIGH IMPACT, ARC RESISTANT PHENOLIC COMPOUND is said to have the same arc resistance properties of melamines and polyesters, but without the variation in properties often associated with these two resins. The material, an asbestos cord-reinforced phenolic resin has an Izod impact strength of 5, a flexural strength of 22,500 psi, and a tensile strength of 10,000 psi. It is recommended for electrical parts such as sockets, connectors and receptacles.

EXTREMELY PURE SILICON for use in such electronic devices as transistors, rectifiers and diodes is now available. The silicon, made with a new process, has boron impurities as low as two parts per billion and electrical resistivities as high as 400 and 500 ohm-cm. The ultra pure silicon presently sells for $250 to $350 per lb.

RUSTY, CHROMIUM PLATED STEEL PARTS may be a thing of the past with use of a zinc base plate in a copper-nickel-chromium plating sequence. The zinc base plate gives galvanic protection to the steel part which stops cracking and peeling of the chromium electroplate. The new method, still in the development stage, apparently overcomes drawbacks of previous attempts to use a zinc base plate. (More details next month.)

A NEW BUTYL RUBBER vulcanizes rapidly without sulfur, resists heat and flexing, and is compatible with natural rubber and GR-S. The new rubber is presently being evaluated as a liner in tubeless tires. Previous butyls could not be made to adhere sufficiently to other rubbers for this purpose.

TWO NEW INSULATIONS FOR NUCLEAR REACTORS are said to be only slightly damaged by neutron and gamma exposure. The materials are an alumina-silica body in felt form and a pure silicon dioxide in batt form. The alumina-silica undergoes a slight reduction of thermal conductivity during exposure but returns to its original value after removal from the reactor.

A 24-CARAT GOLD COATING can be applied to metals with a new immersion gold solution that requires no electrical current or special equipment. According to the producer, the solution produces a denser, better looking coating than conventional gold electroplates. It is recommended for coating bottle caps, radio knobs, metallized plastics and auto trim. (More details next month.)

A PLATINUM ALLOY ROD is being used in jet engines to eliminate engine flame-out. Since platinum retains heat for long periods of time, the rod is kept at combustion temperature by the engine's regular operation and acts as an automatic pilot light when flame-out occurs. According to the producer, the rod requires no electrical connections, moving parts or maintenance.

COPPER, ALUMINUM AND STEEL FIBER-REINFORCED PAPERS have been made in the laboratory. The papers, made of metal and glass or cellulose, can be fabricated on regular paper-making equipment using special techniques. Thermal and electrical conductivity, chemical reactivity and magnetic properties can be built into the papers, according to the producer.

A HEAT RESISTANT CERAMIC COATING developed recently is said to be more resistant to mechanical shock than porcelain enamel. The material, an aluminum silicate in a colloidal solution, can be baked at temperatures as low as 350 F. The resultant coating is said to withstand temperatures above 1100 F and is resistant to sea water.

Turn to page 155 for more "What's New in Materials"

MATERIALS BRIEFS

Tapping the Sun

Tiny silicon converters can store enough solar energy to supply the needs of an average household. Such converters make solar energy economically feasible now as a power source in regions where fuel is expensive.

Plastics and Potatoes

Melamine plastics dinnerware is now being used in about 35% of all restaurants in the United States, according to recent reports. The plastics dinnerware is said to be durable, lightweight and easy to wash.

Square Spray

A square vinyl plastics lawn sprinkler is designed to sprinkle corners and hard-to-cover areas with a low pressure spray that soaks deep into the ground.

How to Be Cool-Headed

An aluminized nylon fabric is being used in a new golf cap. It is claimed that the cap reflects 95% of the sun's radiant heat and keeps the golfer's head 20° F cooler than other caps.

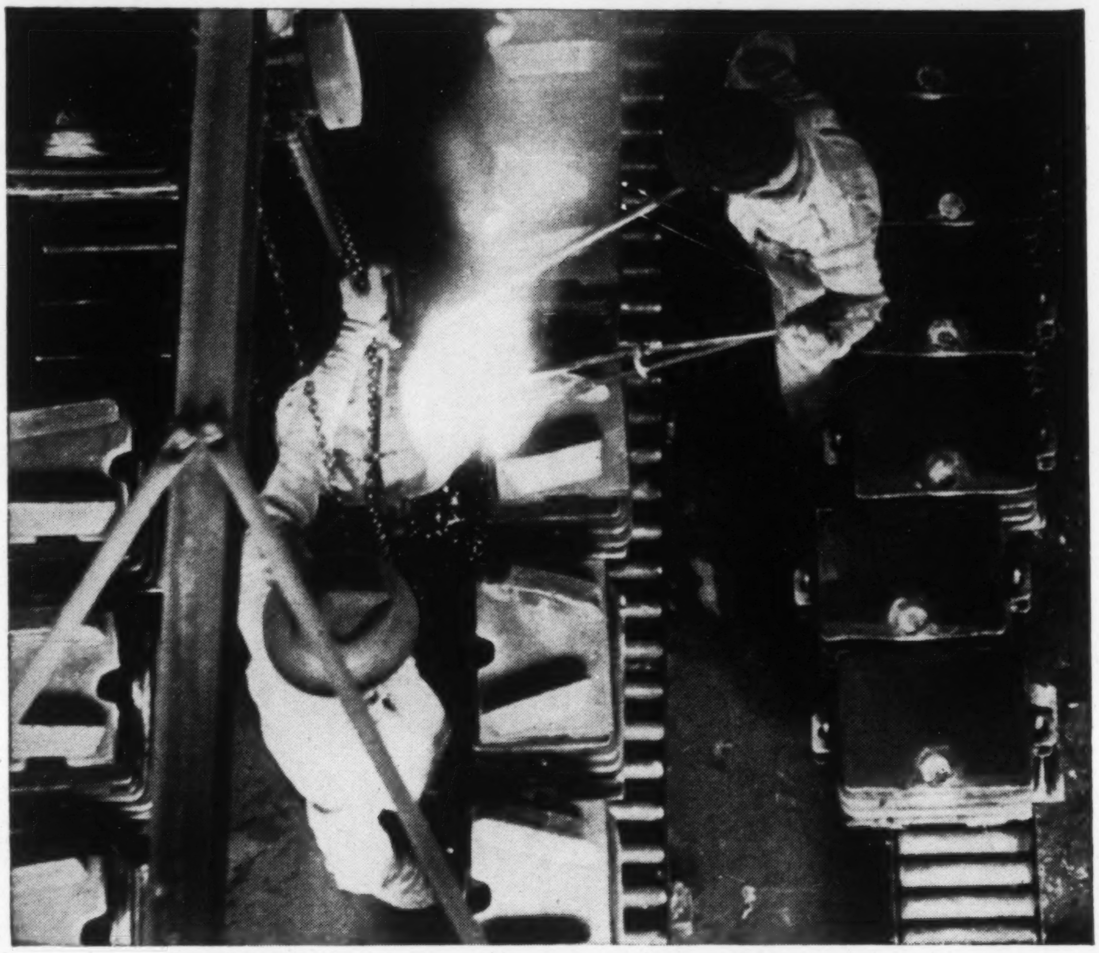
Big Swim

The largest, prefabricated, reinforced plastics swimming pool in the world has just been completed. Made of fibrous glass-reinforced polyester resin, the pool measures 92 ft long and 36 ft wide.

No Sunburn?

A beryllium disk is being tested as a light-collecting mirror in a solar telescope. The disk is of potential value because it may be able to face the sun and absorb its heat without getting out of shape.

Have you had trouble with Engineered Bronzes?



The truly engineered bronzes . . . silicon, aluminum and manganese bronzes . . . give desirable combinations of properties not available in any other metals.

If you need the physical characteristics of the engineered bronzes, but if you have had difficulty in achieving them in castings, it will be worth your while to try again with Federated products.

It is difficult to make these bronzes and only many years of experience and rigid quality control will produce the metallurgical qualities desired. At Federated, ingredient specifications are adhered to rigidly. Continual spectrographic and chemical controls are used during the alloying process. Experienced metallurgists are in charge. Performance specifications are always met or exceeded.

Let us tell you more about these valuable alloys. A Federated field man will be around to see you soon. Talk to him. It will benefit you.

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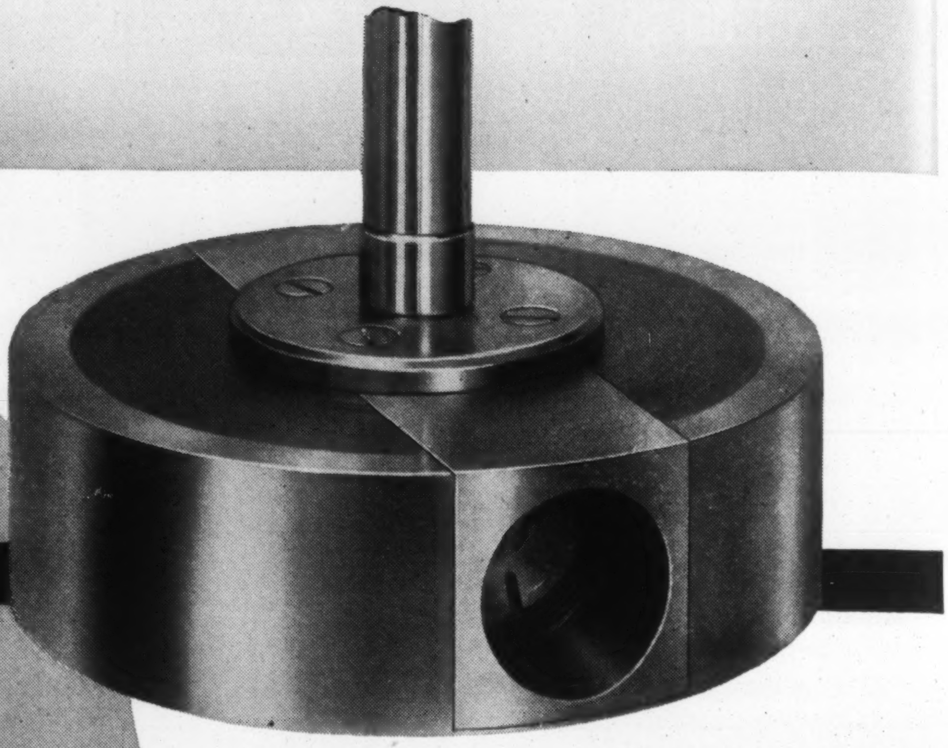
Mallory 1000 Metal



Cobalt 60 teletherapy machine source wheel—of Mallory 1000 Metal.

Radiation shielding 40% more effective than lead

In the design of radiation shields, the superior uniformity of Mallory 1000 Metal is an important quality. It permits calculations based on precisely controlled absorption characteristics rather than "average" or "typical" values. You can design smaller parts and reduce overall costs by minimizing safety factor allowances.

Mallory 1000 Metal is being used for shielding of source capsules, "switching" devices and other radiation shielding applications at energy levels to 100 MEV. Mallory 1000 has high tensile and flexural strength—machines readily to close tolerances and excellent surface finishes.

For application assistance—see the Mallory engineer . . . for more complete information, write for your copy of Technical Bulletin 6-7C.

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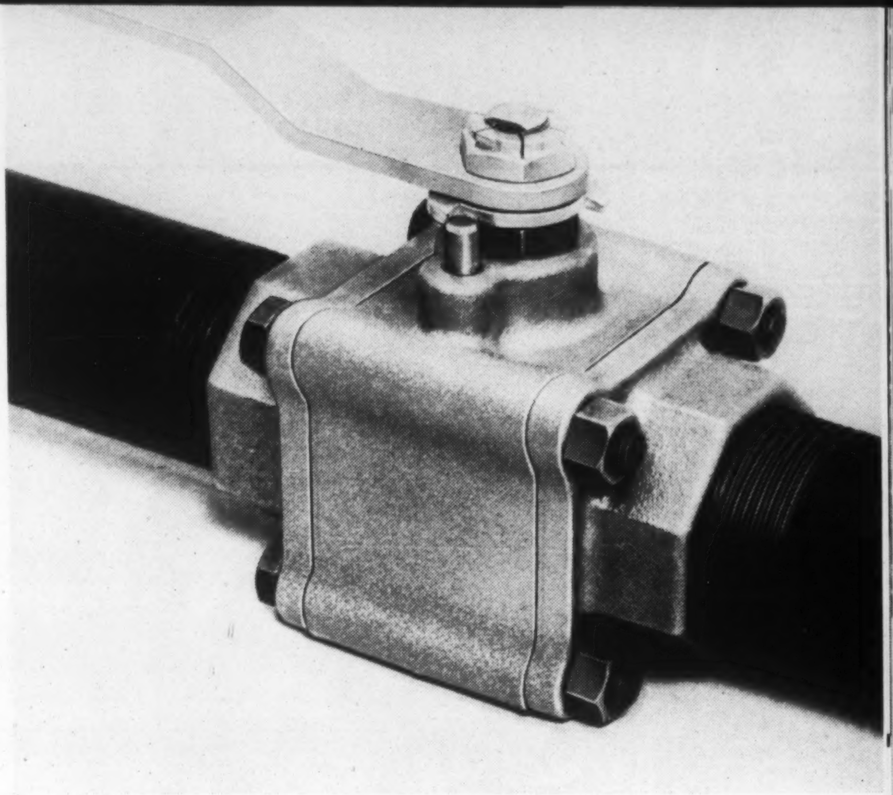
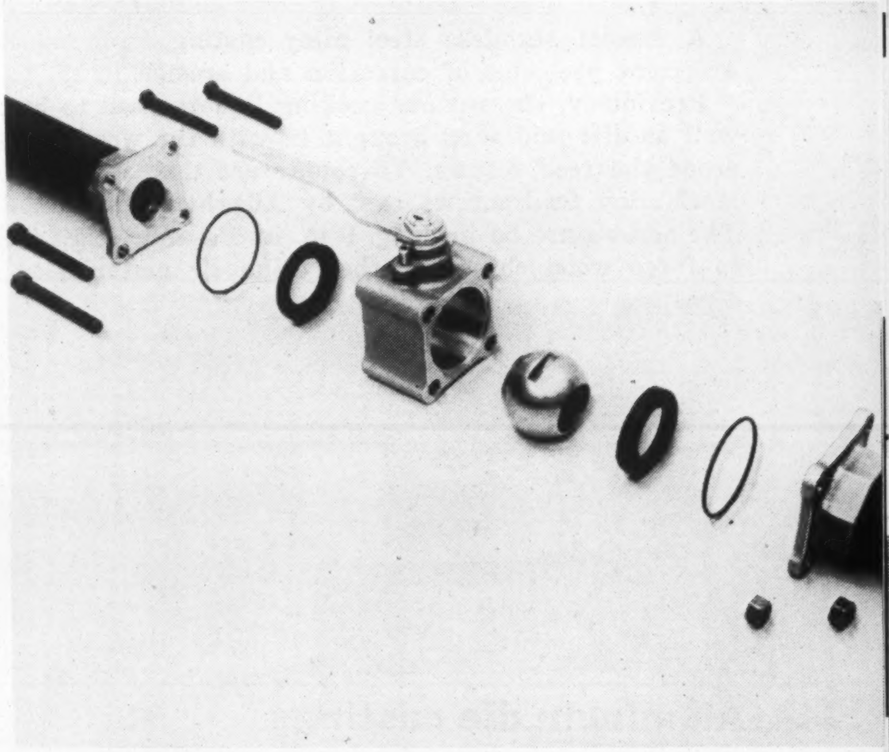
MATERIALS
AT WORK

New
and interesting
applications
of engineering
materials



Combination *union and ball valve allows . . .*



. . . interchanging of components *made of several different materials.*

Valve combines two functions, ten different materials

A new valve combining the functions of union and ball valves in one compact unit is designed so that seat and seat materials can be interchanged in order to accommodate a variety of media.

The combination valve, developed by Worcester Valve Co., Inc., uses metal components which may be of bronze, aluminum bronze, aluminum, carbon steel or stainless steel. Seat and seat materials may be of Buna-N, Hypalon, neoprene or natural rubber, or Teflon. In-line maintenance or change of components is accomplished by simply removing four bolts (see photo).

MATERIALS AT WORK

Cast stainless screw resists pulp liquor

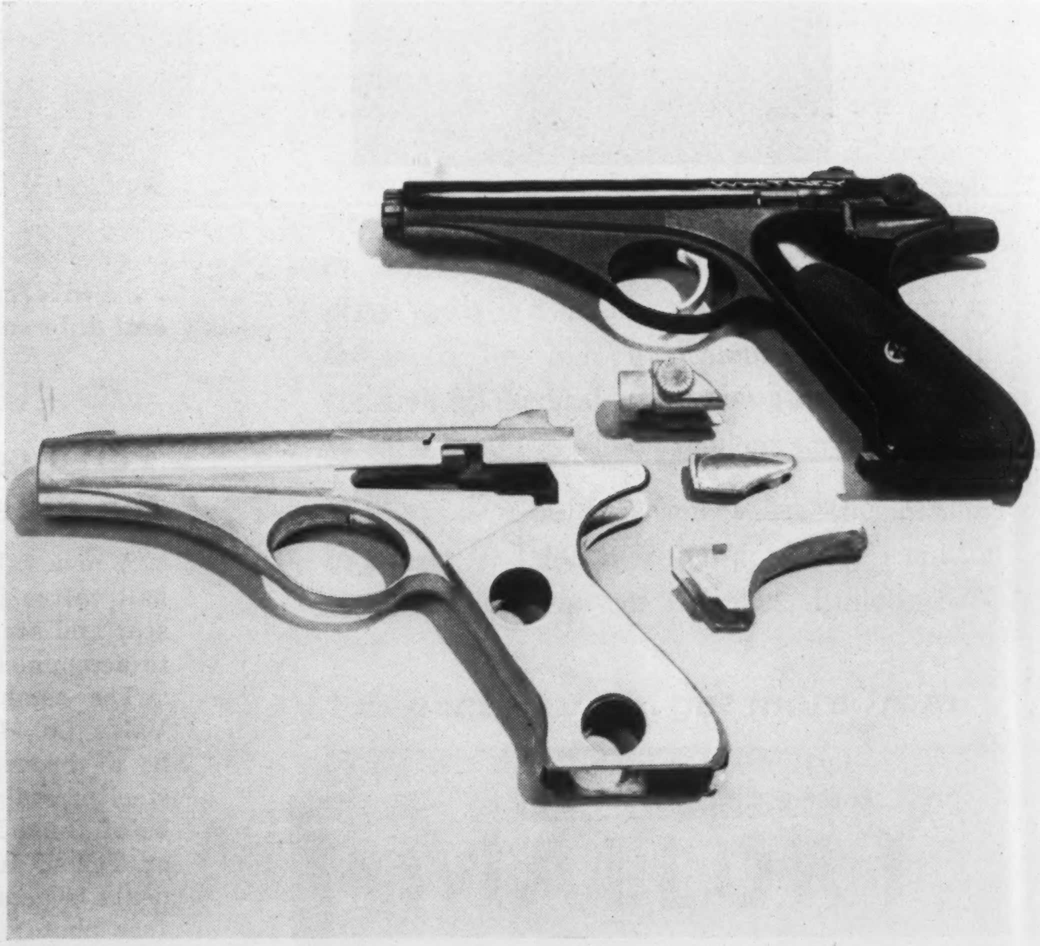
A special stainless steel alloy casting has enabled Black-Clawson Co. to overcome problems of corrosion and erosion in its pulp-making equipment.

Previously, the various cooking liquors used to break down wood fibers, as well as dirt and sand brought in with the wood chips, tended to corrode and erode the feed screws. To counteract this, the company now uses Pandaloy steel alloy feed screws cast by Allegheny Ludlum Steel Corp. (see photo). The screws are 54 in. long, 9 in. in dia and weigh 508 lb each. They are used to force wood chips or other cellulosic material at a constant rate into a digester.

Aluminum die castings used in new pistol

By turning to aluminum die castings, Whitney Firearms, Inc., has eliminated several time-consuming and costly milling, broaching, and profiling operations in the manufacture of its .22 automatic pistols.

The four die castings, a complete one-piece frame, cocking piece, action frame and safety (see photo), are said to provide excellent performance and to be exceptionally strong and light in weight.



Eastman Chemical Products, Inc.

Molded polyethylene for bullet boxes

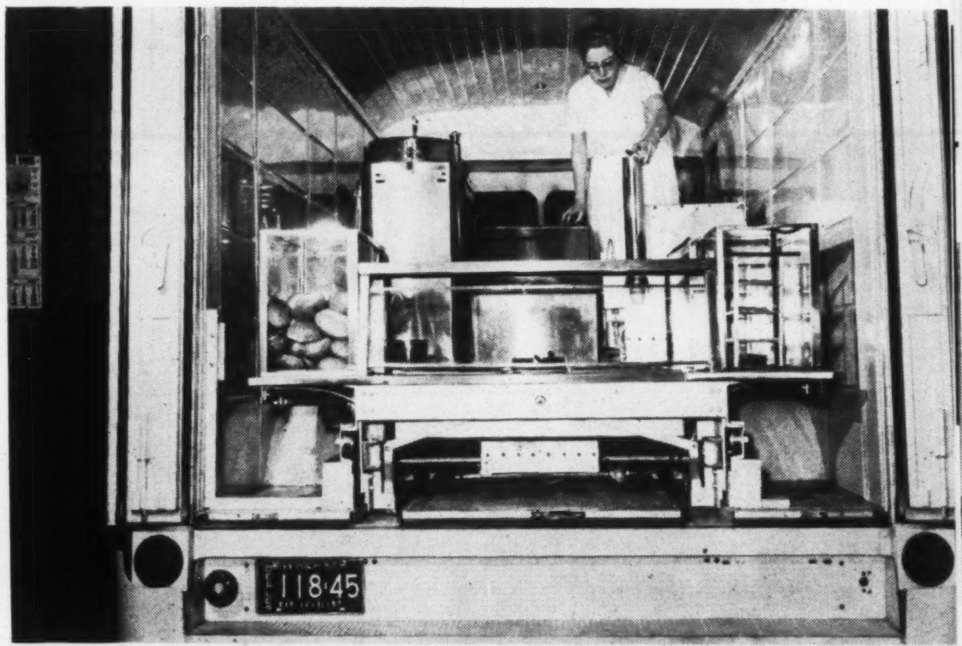
These handy cartridge boxes molded of tough, resilient polyethylene are keeping ammunition clean and dry. Manufactured by Fitz Co., the unbreakable cases are divided into compartments holding one shell each and are ideal for hunters and match shooters.

Stainless steel serves lunch on wheels

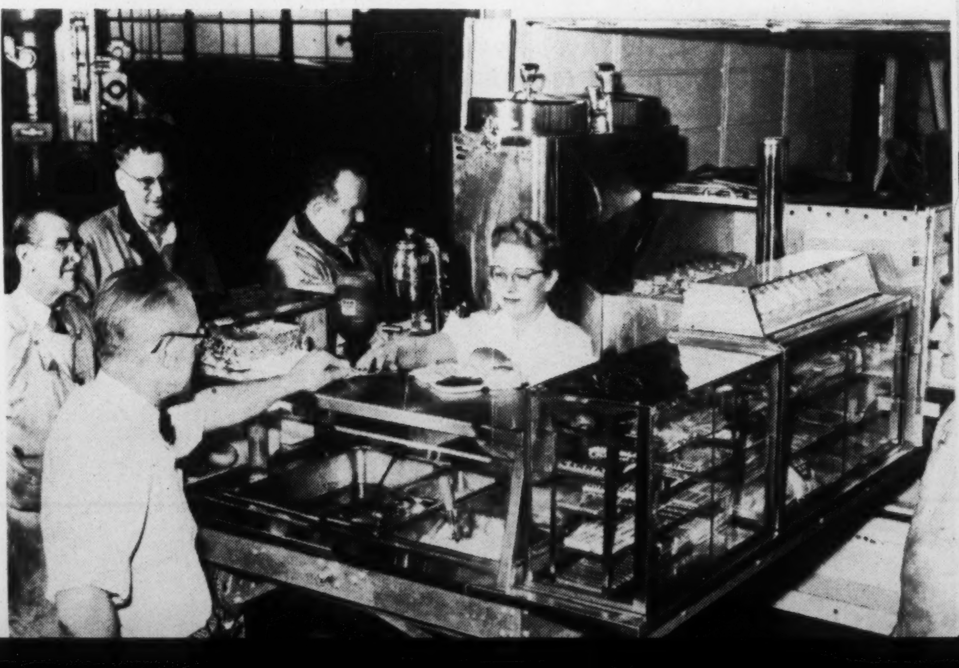
An unusual mobile cafeteria that can be set up in less than a minute by merely pressing a button is built completely of stainless steel.

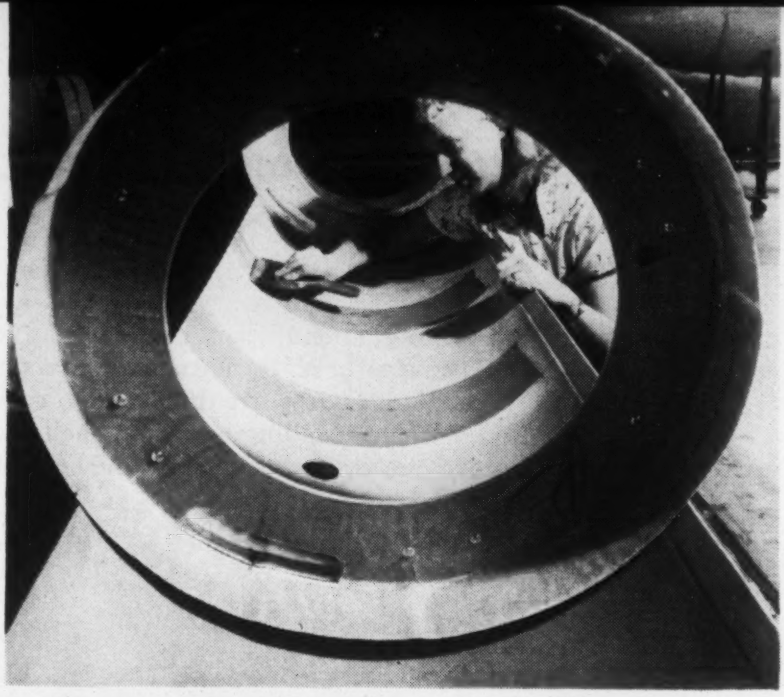
Developed by Roy E. Lowe and called the Autoteria, the unit is built into the van of a 1-ton truck (see top photo). Using power from the truck's battery, the chain driven cafeteria slides out of the van at the press of a button. Wheels resembling airplane landing gear drop automatically and the unit is ready to serve (see bottom photo).

Stainless steel was chosen for all parts of the mobile cafeteria because it is stain and heat resistant, easy to clean and presents a sanitary appearance.



Electro Metallurgical Co., Div. of Union Carbide Corp.





1. Epoxy adhesive *for bonding bulkheads is first applied to center section.*

2. After bulkheads are mounted, *excess adhesive is scraped off.*

MATERIALS
AT WORK

Epoxies provide strong joints for reinforced plastics fuel tanks

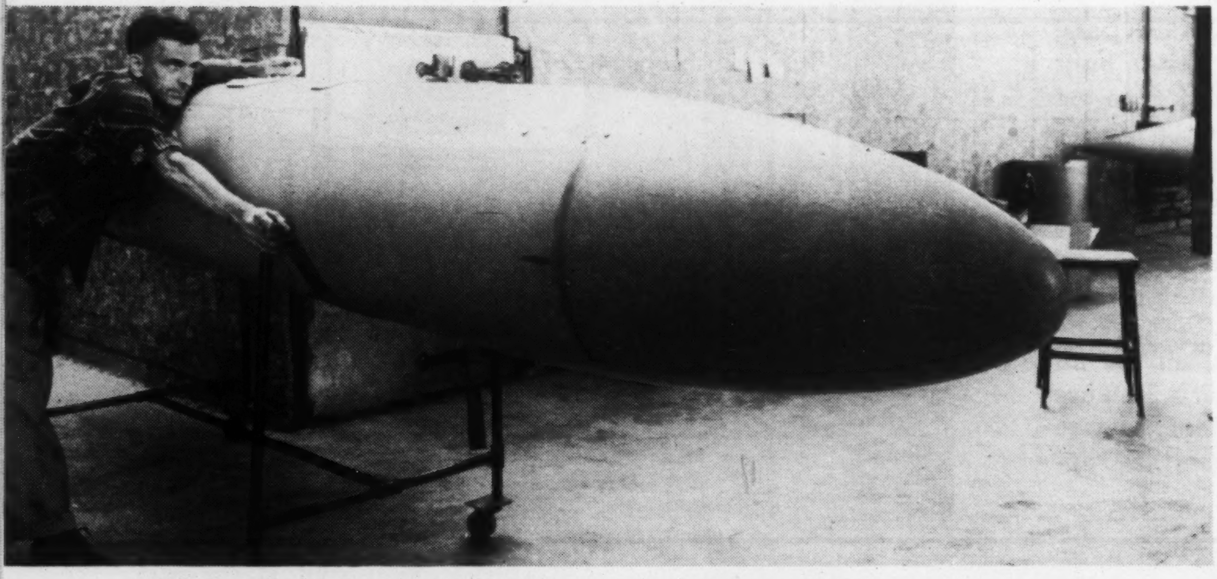
Use of epoxy adhesives is enabling Admiral Corp. to fabricate reinforced plastics jettison fuel tanks having high strength joints that can be cured at low temperatures. The tanks, developed in order to prevent enemy use of strategic aluminum salvaged from jettisoned fuel tanks, are made of fibrous glass-reinforced polyester resin.

The units, 178 in. long with a 23-in. dia, are fabricated on matched metal molds in seven sections: three center sections, a nose, a tail and two bulkheads (used for reinforcing the structure internally). Wall thicknesses are 0.1 in. with the exception of one 0.2-in. thick center section used for attaching a hanger bracket. When sealed together, the sections overlap 1¼ in.

To fabricate the tanks, a fuel filler opening is first cut into one of the center sections and screw holes are drilled in all sections. After coating all mating surfaces with the epoxy adhesive (supplied by Shell Chemical Corp.), the three center section pieces are assembled with the reinforcing bulkheads in place. Interlocking edges of the nose and tail section are similarly prepared and assembled. To eliminate the need for binding the tank while curing the adhesive, small self-tapping screws are used to hold all seven sections together.

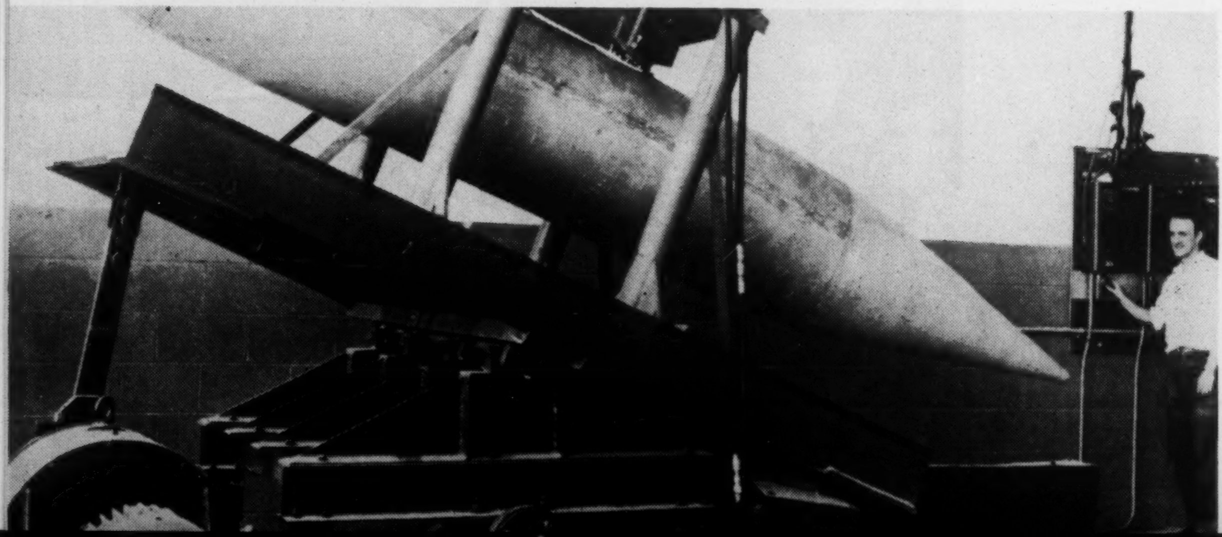
The assembled units can be cured in one of two ways: 1) at room temperature for times ranging from 14 to 24 hr or 2) at room temperature for 1 hr, followed by a 2-hr oven cure at 180 F. After curing, the

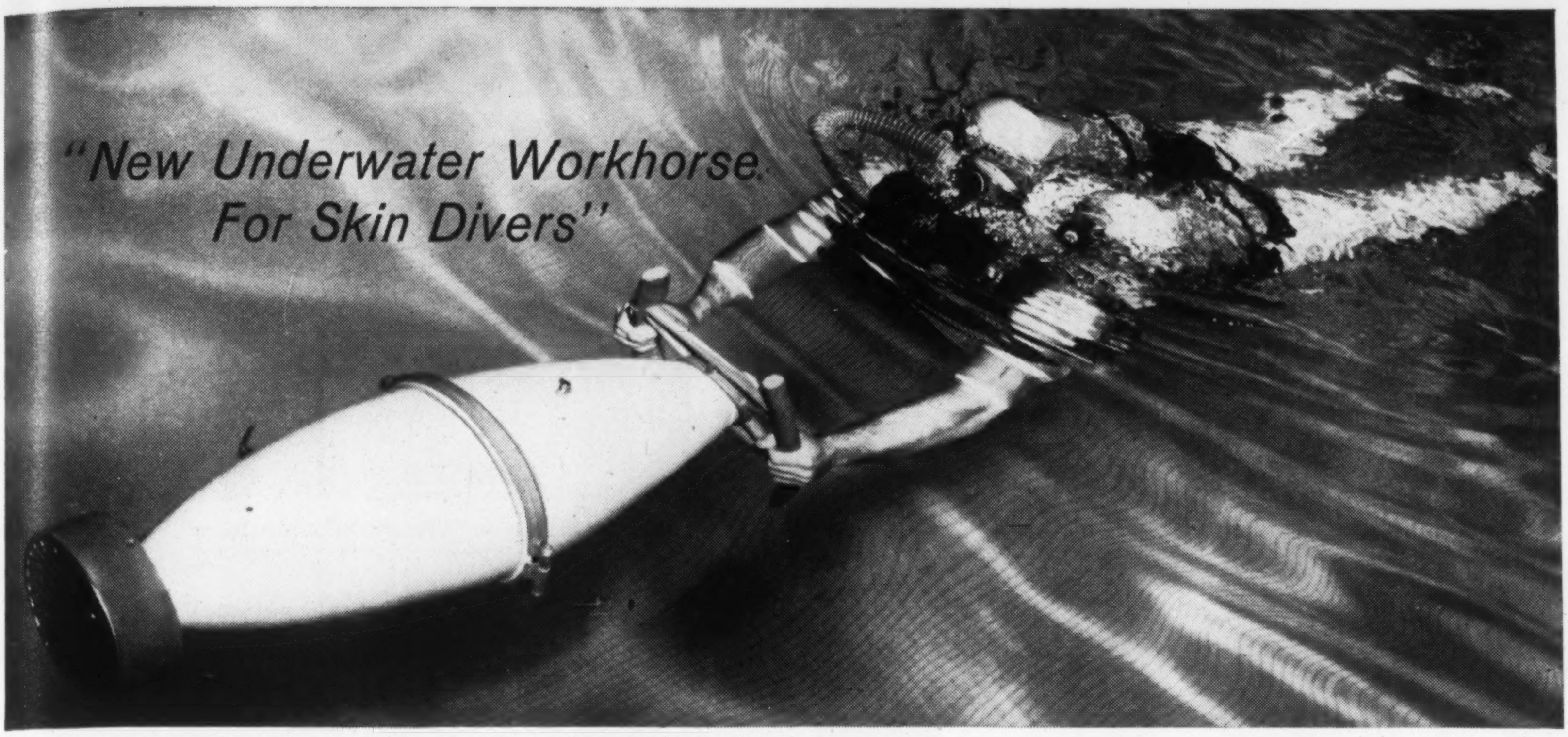
(continued on p 222)



3. Tanks are cured *in 60 ft oven for 2 hr at 180 F.*

4. Completed tank *is given a slosh and vibration test.*

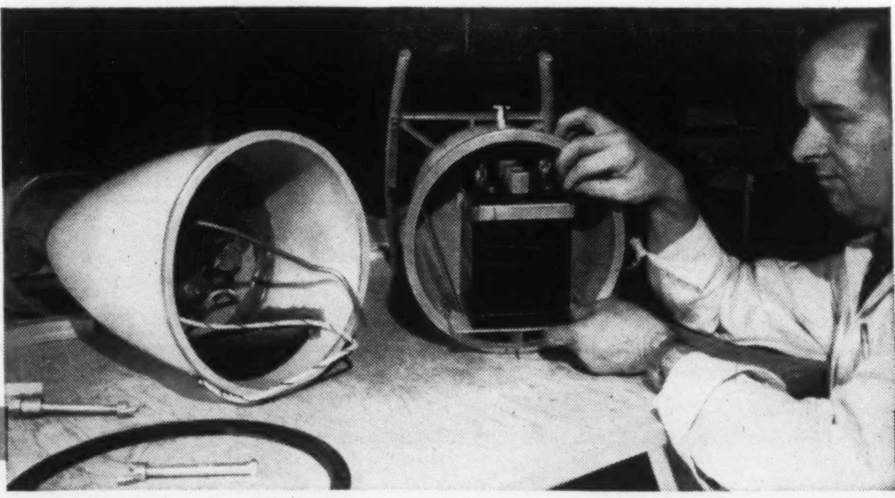




Constructed With Sturdy, Dependable

POLYLITE

Resin



● Top performance under tough conditions . . . that's what's required of these one man underwater propulsion units made by the Link Aeronautical Corporation of Endicott, New York.

The basic shell material for this "Power Diver" must be able to withstand the pressures of 100-foot dives . . . must be able to resist the corrosive effect of the sea . . . and must still be light enough for a man to carry the unit out of the water. These are just some of the physical requirements that must be met for such a product as this . . . and met at a price that doesn't take the product out of the sportsman's reach!

"That's why we chose a combination of RCI POLYLITE and fibrous glass," states Felix Aimonetti, vice president and general manager of Link. "From the standpoint of design, engineering and cost, reinforced POLYLITE was the perfect solution for our shell material.

"Besides all this, the capital outlay we needed for this type of construction was relatively low, and we found that even without the benefit of prior manufacturing know-how during the first weeks of production, we were able to turn out a consistently uniform product. All things considered, the use of RCI POLYLITE reinforced with fibrous glass has cut our production costs at least 75%."

Products possessing the unique advantages of RCI POLYLITE — lightweight strength, durability, and easy maintenance — are becoming increasingly popular and profitable in today's market. Perhaps POLYLITE polyester resin can be incorporated into one of your products. For additional information about what you can do with RCI POLYLITE in laminating, molding or other plastics applications, write for free *Booklet A.*

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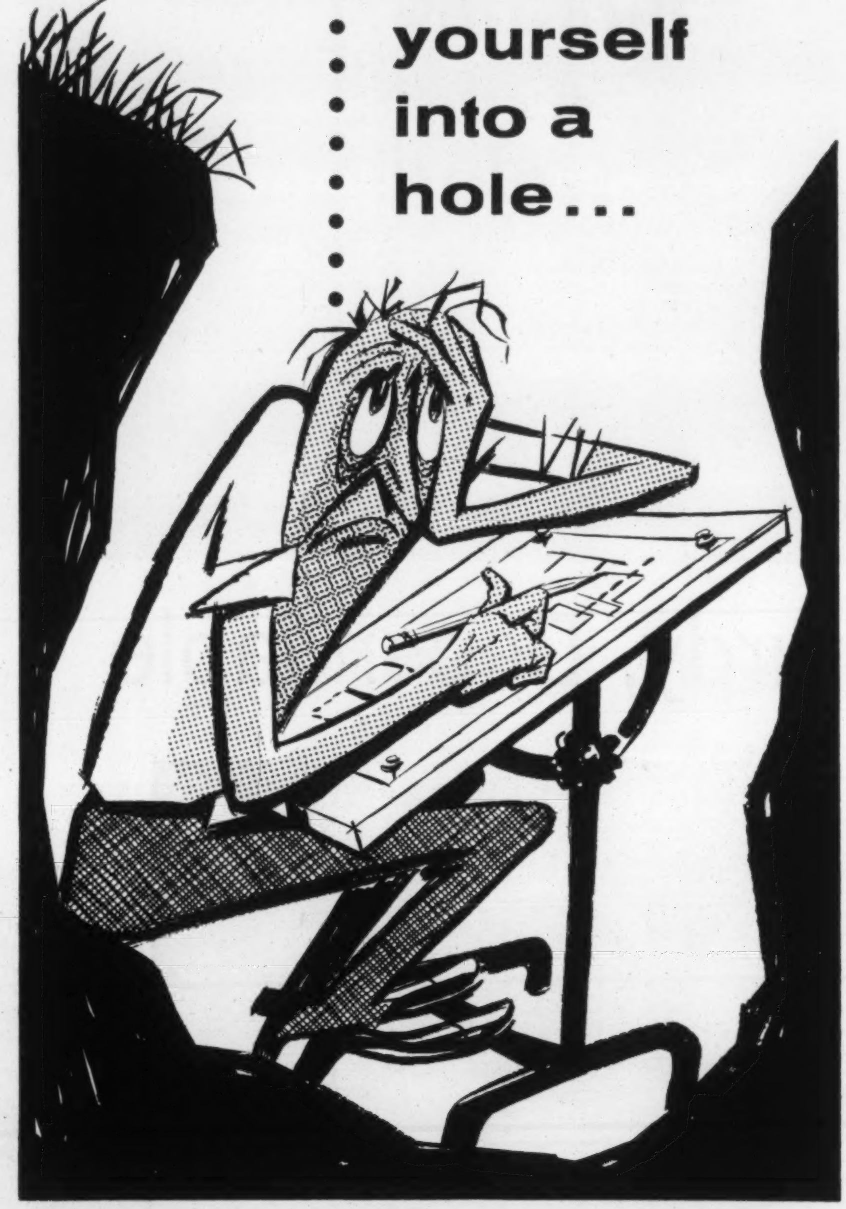

IF you've designed yourself into a hole...

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The unusual qualities of silicone rubber compounds offer opportunities for simpler, more compact designs . . . smaller, lighter units that require less costly material and labor. Stalwart-engineered silicone rubber parts can be used in a wide range of applications involving temperature extremes from —130° to +600° F. with virtually no change in their physical, chemical and dielectric properties.

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For further information write for Bulletin 56-SR-3

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Letters to the Editor

Atomic reactor materials

To the Editor:

In your May '57 issue, page 226, a polyethylene block used as an atomic shield is described.

Mention is made that it is being used as a replacement for lead shields in atomic reactors. Polyethylene is not used as a replacement for lead because polyethylene is a shield against neutrons and lead is a shield against gamma rays. They are therefore supplemental to each other rather than substitutes for each other.

Lead is the most efficient and economical gamma ray shield where space and weight savings are important. It is the high density of lead which makes it so efficient for this purpose, and a low density material like polyethylene does not stop gamma rays. In this the manufacturer of the product described concurs with us.

ROBERT L. ZIEGFELD
Secretary
Lead Industries Assn.
New York, N. Y.

We are grateful for the correction and take this opportunity to bring it to the attention of our readers.

Slighted author

To the Editor:

The article entitled "Comparison of Plastics as Fuel Hose Liners" on page 183 of your July issue was based on a paper of which I am senior author. Although the names of the other two authors were given, mine was not. I would appreciate a correction. Incidentally, I will be glad to send a chart listing gas sorbency values of various elastomers and plastics to anyone desiring it.

FLORENCE NESH
Code 972
Materials Laboratory
New York Naval Shipyard
Brooklyn, New York

We regret the omission which, of course, was inadvertent.

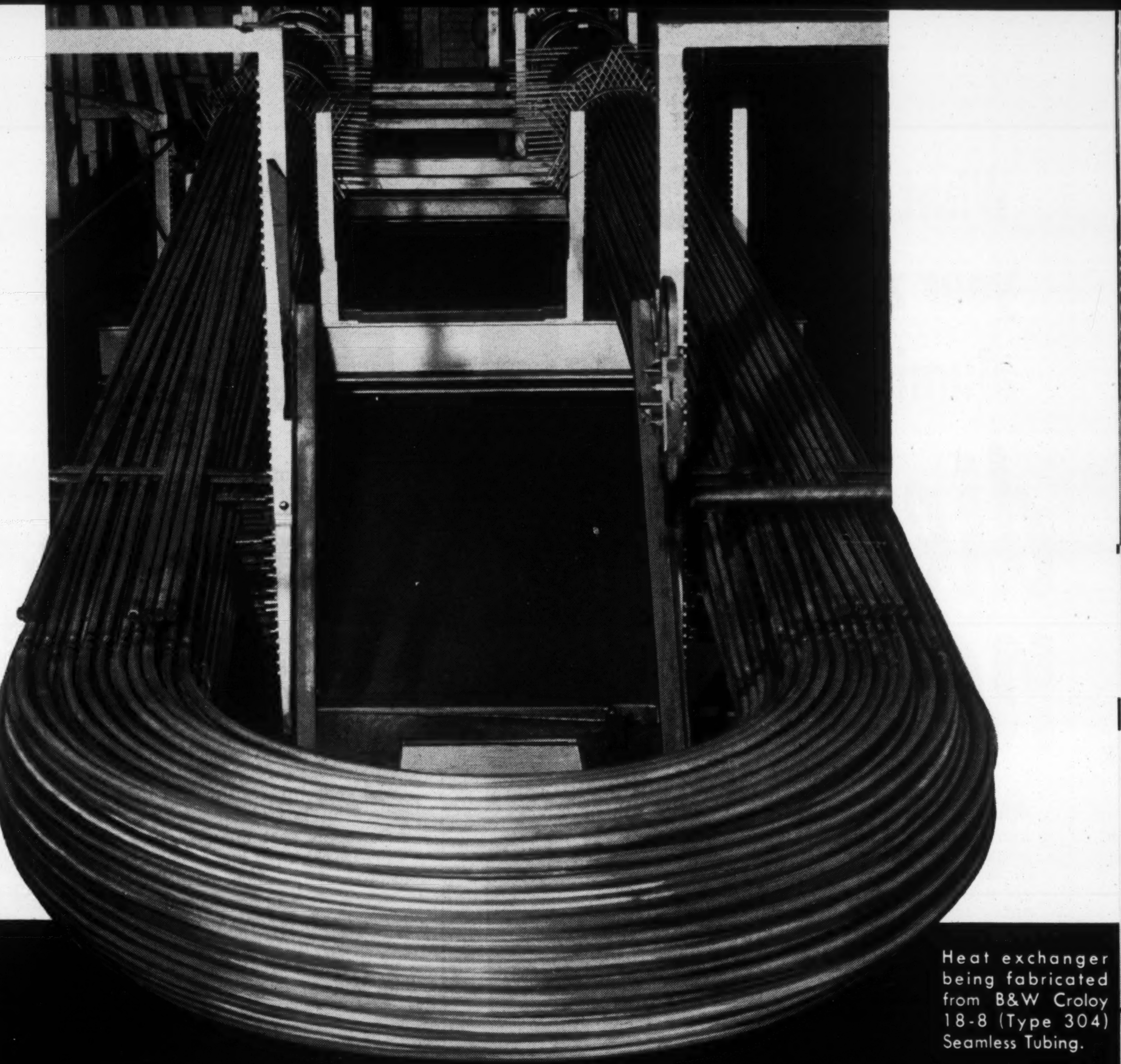
Staying in harness

To the Editor:

The discussions on engineering aides have interested me greatly. However, it seems to me that one possible solution has been overlooked.

In a few years I shall retire after many years as a machine design engineer. I shall not wish to sit back and stagnate. I would be very glad to take a position—part time or full time—as an engineering aide.

I feel sure many other engineers who have been



Heat exchanger being fabricated from B&W Croloy 18-8 (Type 304) Seamless Tubing.

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Letters
to the editor

forced out of circulation because of age alone would be glad of the opportunity to practice even part of their chosen line of work. They would offer the much needed relief from repetitious detail that younger engineers loathe, and increase efficiency in any engineering line, putting long experience to good use.

W. P. Grillet
Pompton Lakes, N. J.

Inorganic elastomers

To the Editor:

Your article on the Fluoro-Elastomers in the July issue of MATERIALS IN DESIGN ENGINEERING was very interesting and informative. We are interested in particular in the paragraph on inorganic elastomer systems. We are encouraged to find that a research program is being initiated for we feel that the need for such materials is imminent.

We would appreciate receiving more information concerning the research programs which are concerned with these inorganic elastomers and would also like to know which of the companies discussed in your article are doing reseach in this field.

V. R. Miner
Material-Engineering Coordinator
Boeing Airplane Co.
Seattle, Wash.

The bulk of the work in inorganic elastomers has been done by nonprofit institutions and universities, either independently or under government contract. For specific information, contact Mr. E. R. Bartholomew, Commander, Attn: WCRTR-3m Wright Air Development Center, Materials Laboratory, Directorate of Research, Wright-Patterson Air Force Base, Ohio.

Testing drapery cord

To the Editor:

We are manufacturers of drapery hardware as well as traverse rods and we use large quantities of traverse rod cord. We find that we have a wide variation in quality of cord as received from our suppliers, and we are anxious to set up our own means of testing this cord to see that it falls within the specifications. We are wondering if you can refer us to a cord and twine association of some kind that could give us information on testing these materials, or refer us to someone who can tell us how to set up and proceed with testing drapery cord.

A. H. Steenrod
Chief Engineer
Western Newell Mfg. Co.
Freeport, Ill.

We suggest contacting Drapery Hardware and Curtain Rod Manufacturers Assn., 53 Park Place, New York, N. Y. and the American Society for Testing Materials, 1916 Race St., Philadelphia 3.

ANNOUNCING THE—

1957-58 AWARDS COMPETITION

FOR THE BEST USE OF MATERIALS IN PRODUCT DESIGN

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. . . is proud to announce that it will again sponsor an Awards Competition to encourage sound, imaginative and progressive use of engineering materials and to reward those responsible for exceptional examples of intelligent materials selection and use.

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. . . totaling $1600 will be given by a distinguished board of judges for the entries best demonstrating how intelligent materials selection 1) resulted in improved performance and/or lower costs, or 2) best met design and service requirements.

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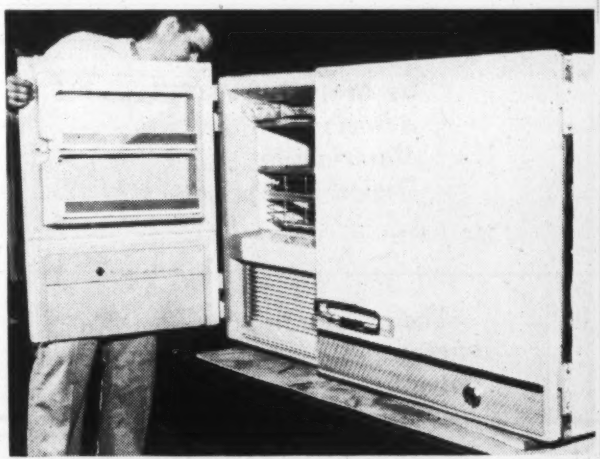
. . . completed during 1957 may be entered. Any person (s) or organization employed in the product manufacturing industries may submit entries. Materials producers and suppliers are not eligible. The deadline for mailing entries is Jan. 15, 1958. So it is not too soon to plan or prepare your entry.

Complete details . . .

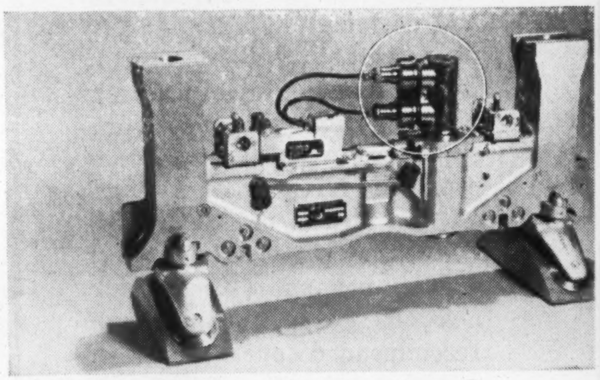
. . . on the Awards Competition and an entry blank will be published in next month's issue (October) of MATERIALS IN DESIGN ENGINEERING. If you would like an entry blank sooner, write to:

AWARDS EDITOR
MATERIALS IN DESIGN ENGINEERING
430 PARK AVE.,
NEW YORK 22, N. Y.

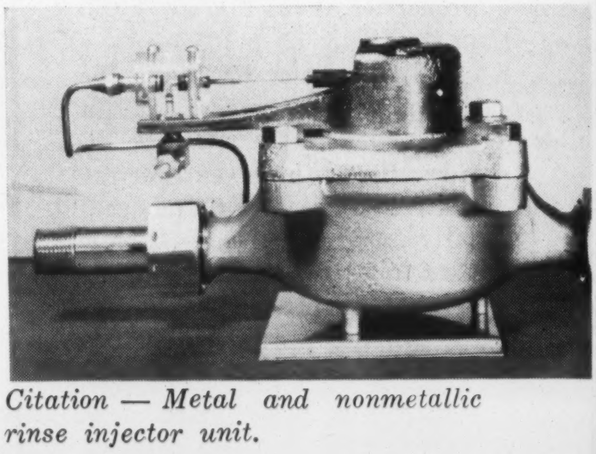
Here are some 1957 winners . . . Our first Awards Competition was an outstanding success in both the number and quality of entries received. This year's will be even better.



First Award — Plastics foam sandwich refrigerator.



Award of Merit — Titanium breech for bomb ejector rack.



Citation — Metal and nonmetallic rinse injector unit.

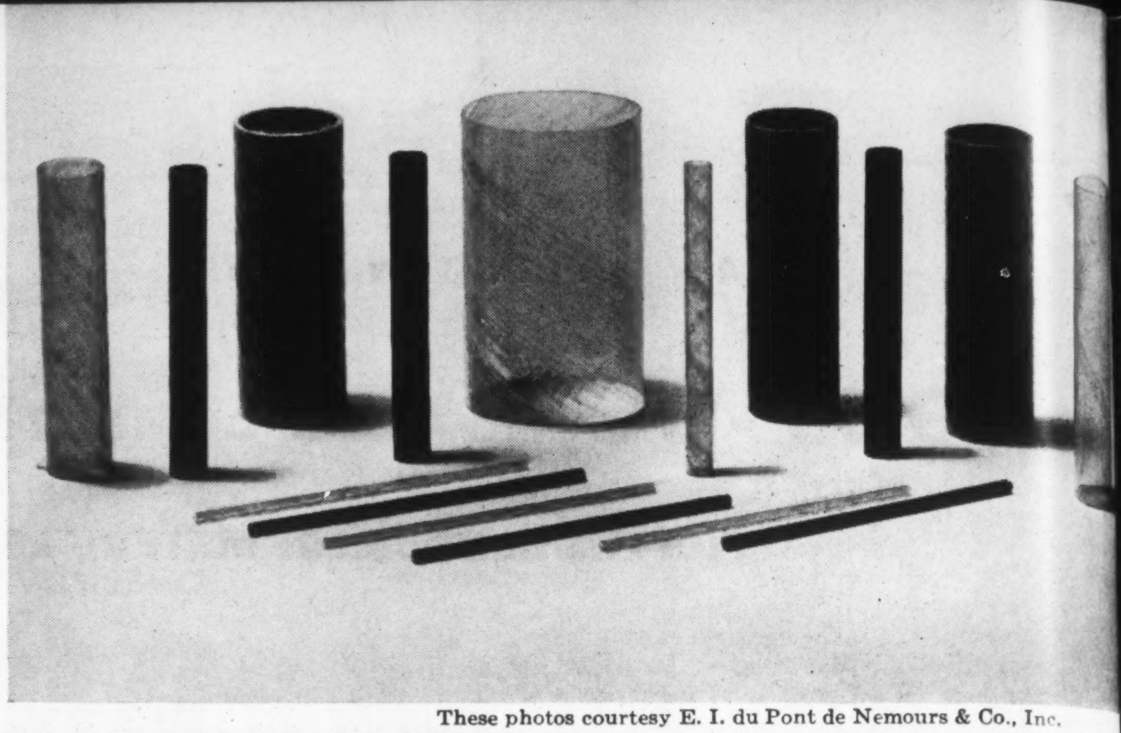
FEATURE
ARTICLES

Where to Use Polyester Film

by Malcolm W. Riley,
Associate Editor,
Materials in
Design Engineering

The extraordinary growth in engineered applications of polyethylene terephthalate type polyester film is attributable mostly to 1) its extremely high mechanical and dielectric strength, 2) its good thermal and chemical stability, and 3) its adaptability to decorating by metallizing or other techniques. Strongest of the unsupported plastics films, polyester film has a tensile strength on the order of 20,000 psi. Dielectric strength is about 4000 v per mil (1 mil thickness, 60 cps), and maximum recommended operating temperature is about 300 F (melting point: 480-490 F). Other properties of the film are given in the tables on p 108.

Polyester film has been put to many and varied uses. In this article these uses are divided into three categories: electrical, mechanical and decorative. There is no attempt here to be comprehensive; the primary purpose is to point out the properties of the film that make it suitable for each type of application, and to describe typical uses.


These photos courtesy E. I. du Pont de Nemours & Co., Inc.
Spiral wound tubular insulation

1. Electrical applications —

■ Electrical applications for polyester film include insulation for motors, generators, transformers, capacitors, and wire and cable; overwraps for batteries; and magnetic tapes. Because of the high dielectric and mechanical strength of the film, thinner gages can be used, reducing bulk and weight of insulation systems. The film can be used either by itself or in combination with such materials as rag paper, asbestos, glass cloth, mica paper or mica splittings.

Properties

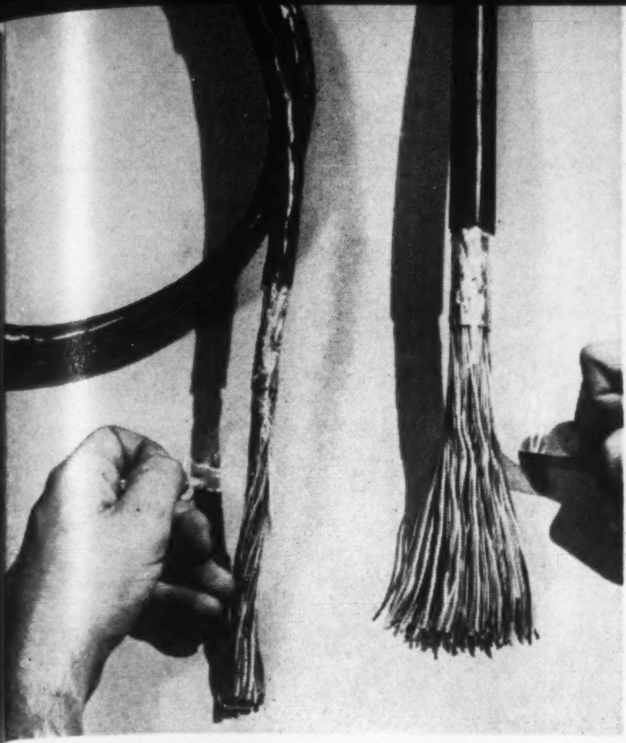
Dielectric strength of polyester film 1 mil thick is 4000 v per mil (60 cps); dielectric strength can be as high as 2500 v per mil for thicknesses of 0.007 in., and 7500 v per mil for thicknesses of 0.00025 in. The film also has good volume and surface resistivity, a good dielectric constant and a low power factor (see table, p 108).

Since polyester film is an organic material, it is designated by the present classification a Class A insulating material. Actually, its thermal stability is such that it falls somewhere between Class A (220 F) and Class B (266 F). It has been used in equipment approved by Underwriters Laboratories for Class B operation. At 300 F, the maximum recommended use temperature of the film, dielectric strength of 1-mil film at 60 cps has only dropped to 3150 v per mil. After 1000 hr at 300 F, dielectric strength is still over 2000 v per mil. This value is also retained after 1000-hr exposure to temperatures as low as –76 F.

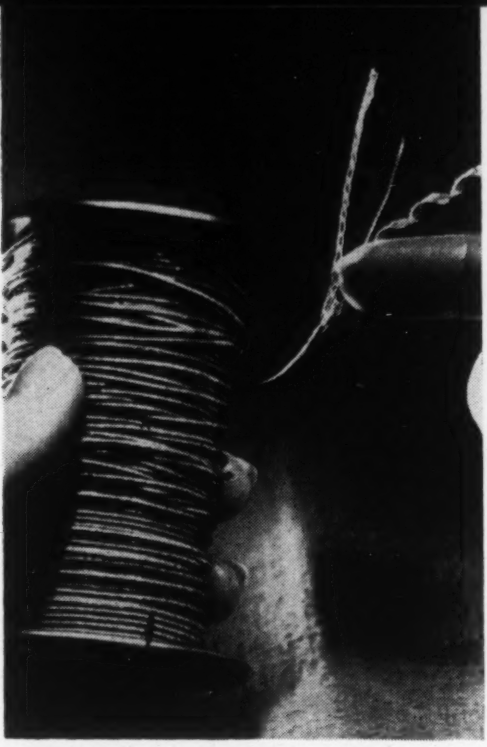
Applications

Motors, generators—In motors, generators and transformers, polyester film is used as insulation for formed and random wound coils, and as phase separators, slot liners and layer insulation. In motor and generator applications the thinner gages of polyester film used can result in generation of more power in smaller frame sizes. Also, the stability of the film when exposed to moisture or elevated temperatures permits use of general purpose equipment in many environments usually requiring specialty construction. The film will not wick water into coils, and it absorbs less than 0.5% water (1-week immersion). It is also inert to toluene, gasoline, acetone, lubricating oils and greases.

Capacitors—In capacitors, the



Cable insulation



Telephone wire insulation

Slot liners

toughness, flexibility, greater efficiency

high dielectric strength of polyester film permits reduction in size and weight, and results in reduced leakage and dielectric losses, making the capacitors more suitable for use in subminiature assemblies. Because of its low moisture absorption, polyester film is less sensitive to high humidity and, in some cases, eliminates the need for sealing the capacitor in metal tubes to prevent short circuits in high humidity applications. It assures permanent insulation between the capacitor foils.

Wire, cable—The toughness of the film (20,000 psi tensile strength and 70% elongation at break) and its chemical inertness, together with its good dielectric qualities, have been mainly responsible for its growing acceptance. Wire or cable insulated with the film can be bent or drawn over sharp corners without damaging the insulation. Also, thickness and bulk of insulation can be reduced. One producer of telephone switchboard wire reports that use of polyester film as primary insulation increased production 35 to 45%. The film used to insulate these particular wires is in tape form, and is only one-half the thickness of the insulation previously used, yet it provides superior mechanical and insulating properties.

Other uses—As an overwrap for dry cell batteries, polyester film offers a unique advantage in that its transparency permits visual inspection of the cells prior to final assembly. In magnetic tapes, the stability and toughness of polyester film permits reduction in tape thickness, increasing the amount of recording time per tape.

What Is Polyester Film?

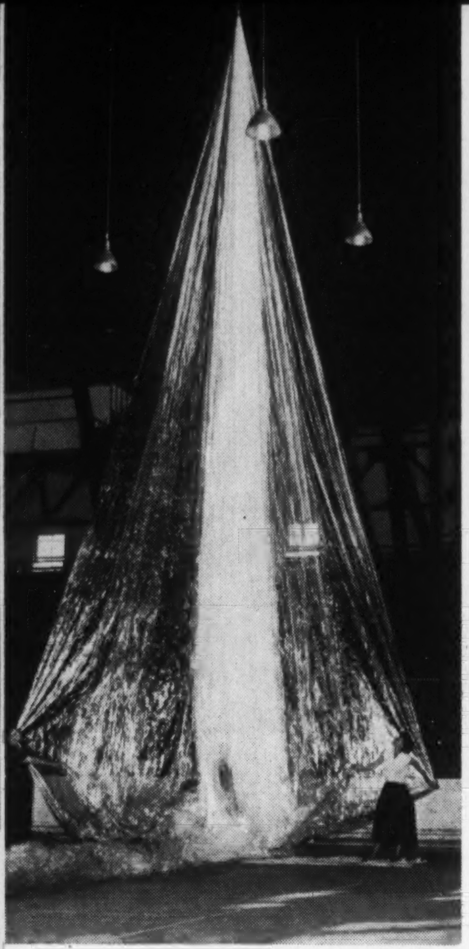
The generic label "polyester" refers to an extremely broad group of materials produced by the esterification reaction between polybasic acids and polyhydric alcohols. For the purpose of this article "polyester film" refers primarily to the polyethylene terephthalate film developed by E. I. du Pont de Nemours & Co. and trademarked Mylar. The only exception is Minnesota Mining and Mfg. Co.'s heat sealable Scotchpak polyester film, developed primarily for packaging (see mechanical applications). The specific chemical nature of this film has not been revealed.

Polyethylene terephthalate type polyester film (Mylar) is produced from a condensation polymer of ethylene glycol and terephthalic acid. Unlike most polyester materials, the film is thermoplastic. However, its melting point is so high (480 to 490 F) that fabricating by conventional thermoplastic techniques is somewhat limited. Essentially, the material is the film version of the polyester fiber, Dacron.

Available types

Commercially available since 1954, Mylar comes in three forms: Type A, a general purpose and electrical film; Type C, for capacitor applications requiring high temperature insulation resistance; and Type D, a highly transparent film with a minimum number of surface defects.

Scotchpak is available in two forms: Type A, heat sealable on one side only; and Type B, heat sealable on both sides.



Du Pont

High altitude balloon

Du Pont

Food conveyor belt

Minnesota Mining and Mfg. Co.

Oil-packed bearing package

2. Mechanical applications — strength,

■ Uses that are primarily dependent on the good mechanical strength and dimensional stability of polyester film include packaging, conveyor belts, scuff strips, and tools and templates. In most mechanical applications, such as packaging, other properties of the film, such as transparency and printability, are extremely important.

Properties

In addition to its high tensile strength, polyester film is relatively stiff, having a modulus of about 550,000 psi. It has outstanding resistance to flex failure; polyester film can withstand over 20,000 flexes, as compared with several hundred for the cellulosics. It has an impact strength of about 90 kg-cm, several times higher than that of other plastics films. Its tear strength is considerably lower than that of polyethylene film, but greater than those of cellophane and acetate films.

Specific effects of various acids, alkalis, solvents and other chemicals on mechanical properties are shown on page 108. In general, polyester film has excellent resistance to attack and penetration by solvents, greases and oils. At room temperature, it has essentially zero permeability to such solvents as ethanol, ethyl acetate, carbon tetrachloride, hexane, benzene, acetone and acetic acid. After two months exposure at room temperature, a 1-mil polyester film is not penetrated by oils and greases such as penetrating oil, lard, cottonseed oil and motor oil. The film is also highly resistant to attack by fungi and bacteria. No reduction in tensile strength or flexibility occurs after burial for 12 months in bacteria-infested soil.

Applications

Packaging — The mechanical properties of the film, combined with its relative insensitivity to oils, greases and acids, its transparency, and the fact that it can be printed and decorated, have made polyester film one of the most versatile of the plastics packaging films. It can be used for packaging foods, dry goods, chemicals or any number of other products. It can be used by itself, or in combination with paper, metal foil, cardboard or other plastics films, such as polyethylene, polyvinylidene chloride (Saran) or polyvinyl chloride. Such combinations permit utilization of the beneficial properties of each material.

An important development from the standpoint of fabricating

References

"Packaging Potentials of A New Film," *Packaging Parade,* Nov '54.

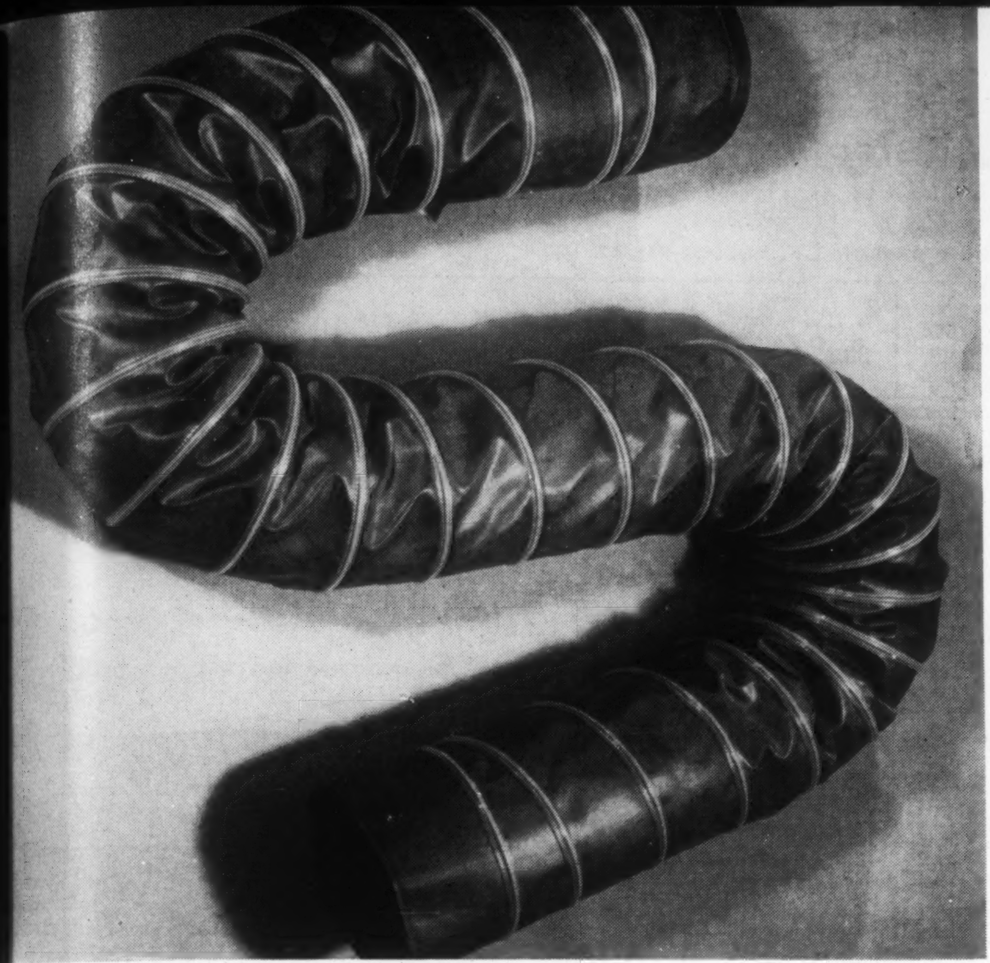
Ruby, J. A., "Mylar," *Volt-Age,* Mar '55.

Wood, W. H., "Packaging Applications for Multi-Layer Structures Containing Mylar Polyester Film." Paper presented at 18th Annual Forum of Packaging Institute, Cleveland, Ohio.

Acknowledgments

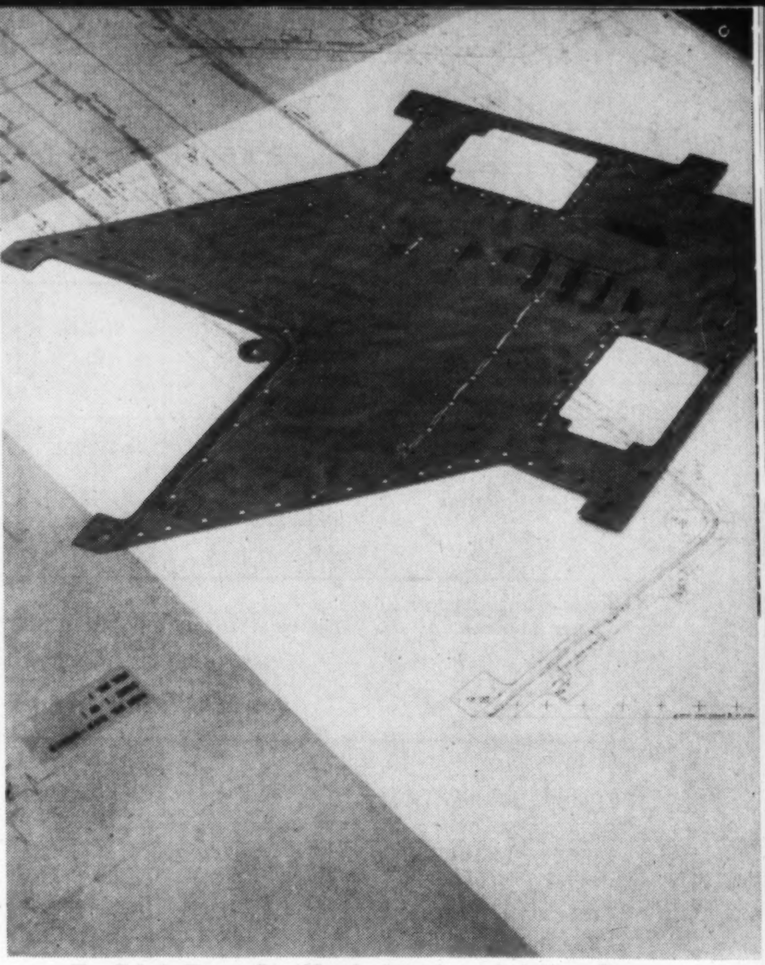
The assistance of literature and personnel of the following companies is gratefully acknowledged:

Bolta Products, Div. of General Tire & Rubber Co.
Dorrie Process Co., Inc.
E. I. du Pont de Nemours & Co., Inc.
Flexible Tubing Corp.
Minnesota Mining and Mfg. Co.
W. J. Ruscoe Co.
Seiberling Rubber Co.
U. S. Rubber Co.



Flexible Tubing Corp.

Scuff strips for air conditioning duct



Keuffel & Esser Co., North American Aviation, Inc.

Stabilized layout film for templates

chemical resistance, long flex life

packages on automatic packaging machinery is the production of heat sealable polyester films. Several companies purchase polyethylene terephthalate type polyester film from Du Pont and apply a thermoplastic coating, such as polyethylene or polyvinylidene chloride, on either one or both sides. Such coated films can be heat sealed by conventional techniques.

Minnesota Mining and Mfg. Co. has developed a heat sealable polyester film called Scotchpak. Although its chemical nature has not been revealed, the properties of the film seem to be substantially different from those of Du Pont's Mylar film. Typical properties of Scotchpak are:

Ten Str, psi	8700
Elong, %	200+
Burst Str, psi	45
Tear Str, gm	25
Temp Limits, F	—70 to 230

Another recent development is a shrinkable polyethylene terephthalate film. This material is intended for "shrink" packaging of foods such as meats and poultry.

Conveyor belting—Polyester film is used as conveyor belting and plaques in baking and candymaking, in pharmaceutical preparation, in tobacco production, and in the manufacture of chemical and rubber products. The film has the mechanical strength and dimensional stability necessary for continued operation in cooling tunnels and other processing areas. It is also easy to clean and resists attack by cooking oils and processing chemicals. Its stability at low temperatures is of particular advantage in processing frozen foods.

Scuff strips—Because of its abrasion resistance, the film is used in scuff strips for portable heater ducts, such as those used to air-condition planes on the ground. The film is applied over the spiral metal support for the duct to protect the fabric from abrasion caused by dragging on the runway.

Templates—Because of the dimensional stability and clarity of polyester film it is used in templates and optical comparators. A proprietary film called Stabiline is Mylar polyester film that has been treated with a process developed by Keuffel & Esser to impart to the film an even higher degree of dimensional stability than that inherent in the untreated film. Treated film has a thermal coefficient of linear expansion of 6×10^{-6} per °F, as compared with a coefficient of 15×10^{-6} for untreated film. The treated film also has a hygroscopic coefficient of linear expansion of about 6×10^{-6} per % RH, as compared with a coefficient of about 11×10^{-6} for untreated film. The increased stability of the film permits greater accuracy of dimension in tooling applications where relatively high temperatures or high humidity are encountered.

Other uses—Polyester film is also used for pressure sensitive tapes, weather balloons, boat sails, luggage, underground pipe wrap, spring liners and gaskets, display racks, signs, and master patterns for knitting machines.

Properties of polyester film (*Mylar type*)

Source: E. I. du Pont de Nemours & Co., Inc., except where noted.

GENERAL COMPARISON OF SOME PLASTICS FILMS

Type of Film ↓	Thickness, mils	Width, in.	Tensile Strength, 1000 psi	Tear Strength, lb/in.	Elongation, %	Maxmium Operating Temperature, F	Brittle Temperature, F	Dielectric Strength, v/mil
Polyester[a]	0.25–7.5	54	15–30	50–1750	35–110	300	–80	1000–7000
Polyethylene	0.5–25	108	1.0–3.5	65–575	200–800	200	–70	100–5000
Vinylidene Chloride	0.5–10	54	1.8–15	80–465	20–140	150–200	–25 to –50	1000–1800
Cellophane	0.9–1.7	45–56	4.5–18	—	15–45	300	—	—
Cellulose Acetate	0.5–10	40–60	5.5–15	—	25–45	150–220	—	700–1200

[a] Polyethylene terephthalate.
Source: Monack, A. J., "Electrical Insulation Materials," *Materials & Methods*, Apr '57.

TYPICAL PROPERTIES OF POLYESTER FILM (Mylar 1 mil thick)

PHYSICAL PROPERTIES

Density (gradient tube), gm/cu cm	1.38
Area Factor, sq in./lb	20,000
Refractive Index (Abbé), n_D-77 F	1.64
Water Absorption (1 wk, 77 F), %	< 0.5
Hygroscopic Coef of Exp (20–92% RH), per % RH	11×10^{-6}
Moisture Vapor Permeability (Du Pont), gm/100 sq m/hr	110
Oxygen Perm (General Foods), gm/100 sq m/hr	0.9

ELECTRICAL PROPERTIES

Dielectric Strength (D 149–44, 60 cps), v/mil	
77 F	4000
300 F	3150
Dielectric Constant (D 150–47T)	
77 F, 60 cps	3.2
77 F, 1 kc	3.1
77 F, 1 mc	3.0
300 F, 60 cps	3.7
Power Factor (D15 0–47T)	
77 F, 60 cps	0.003
77 F, 1 kc	0.005
77 F, 1 mc	0.016
300 F, 60 cps	0.0064
Insulation Resistance (wound capacitor sections, 0.5 mfd megohm-mfd	
212 F	5000
266 F	400
300 F	100
Volume Resistivity (D 257–49T), ohm-cm	
77 F	1×10^{19}
300 F	1×10^{13}
Surface Resistivity (D 257–49T, 77 F), ohm	
0% RH	10^{12}
100% RH	4.8×10^{11}

MECHANICAL PROPERTIES

Tensile Strength (Instron), psi	20,000
Tensile Modulus (Instron), psi	550,000
Elongation at Break (Instron), %	75
Impact Strength (Du Pont falling ball), kg-cm	60
Burst Strength (Mullen), lb	45
Tear Strength (Du Pont single sheet), gm	15
Flex Life (Du Pont, 77 F), cycles	20,000
Bending Recovery (180 deg), %	
Immediate	43
60 Sec	51

THERMAL PROPERTIES

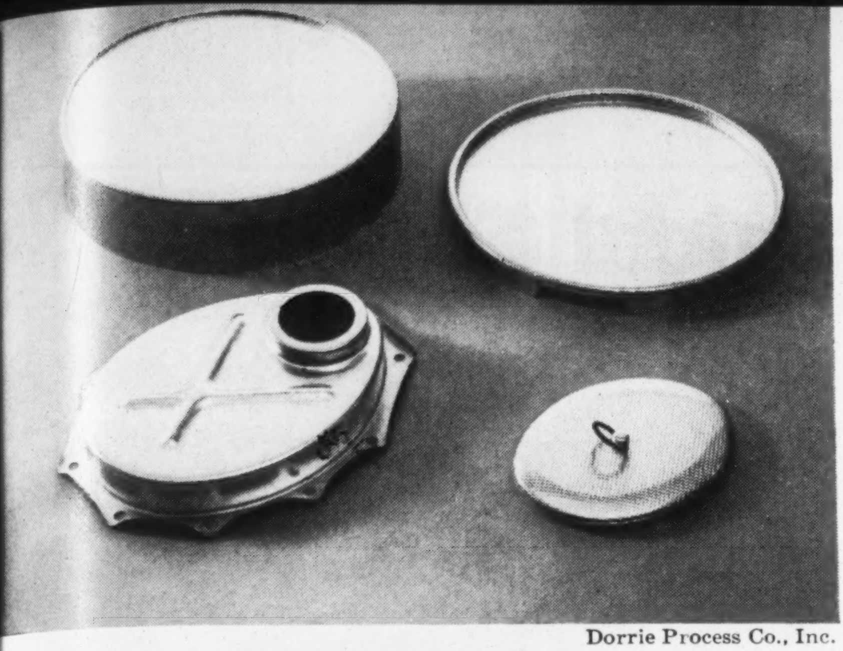
Melting Point, F	480 to 490
Max Rec Svc Temp, F	–80 to 300
Coef of Ther Exp (70 to 120 F), per °F	15×10^{-6}
Ther Cond (Cenco-Fitch), Btu/sq ft/hr/°F/in.	1.05

Source: E. I. du Pont de Nemours & Co., Inc.

EFFECT OF FLUIDS ON MECHANICAL PROPERTIES (1-mil film)

Fluid ↓	Resistance Rating	Retention of Properties After Immersion: Immersion Time (rm temp), days	Ten Str, %	Elong, %	Tear Str, %
Acids					
Acetic (glacial)	Excellent	33	75	107	83
Hydrochloric (18%)	Excellent	18	82	99	113
Hydrochloric (conc)	Good	5	75	87	67
Nitric (35%)	Good	7	71	96	20
Nitric (fuming)	Poor	—	—	—	—
Sulphuric (20%)	Excellent	7	98	89	27
Bases					
Ammonium Hydroxide (12%)	Good	9	59	82	30
Ammonium Hydroxide (conc)	Poor	3	0	0	0
Sodium Hydroxide (10%)	Excellent	33	83	30	33
Solvents					
Acetone	Excellent	33	63	151	67
Dioxane	Excellent	33	80	141	53
Ethyl Acetate	Excellent	33	90	132	47
Solvents (cont'd)					
Trichlorethylene	Excellent	33	66	84	73
Xylene	Excellent	33	91	151	67
Impregnants					
Hydrocarbon Oil (high viscosity index)	Excellent	[a]	92	88	87
Hydrocarbon Oil (low viscosity index)	Excellent	[a]	98	67	123
Pyranol (GE 1467)	Excellent	[a]	100	83	207
Silicone Fluid (DC200)	Excellent	[a]	79	141	97
Varnishes					
Asphalt-Base (GE 9466)	Excellent	[b]	92	18	113
Glyptal Resin (GE 2480)	Excellent	[b]	99	80	60
Phenolic Resin (GE 1678)	Excellent	[b]	92	3	73
Silicone Resin (GE SR80)	Good	[b]	58	230	100
Silicone Resin (GE SR28)	Excellent	[b]	100	54	97

[a] 500-hr immersion at 212 F. [b] 168-hr immersion at 300 F.

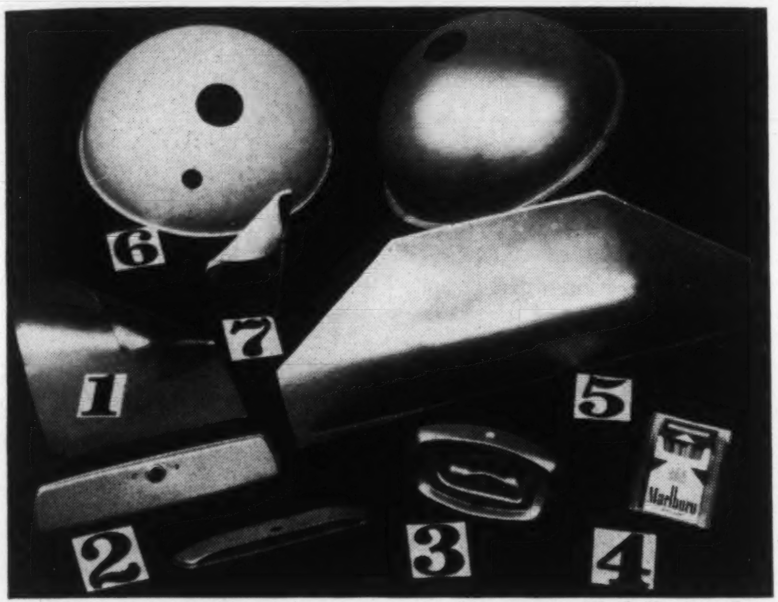


Dorrie Process Co., Inc.

Film-vinyl-steel embossed laminate

Du Pont

Film laminated to fabrics



W. J. Ruscoe Co.

1-4: film laminated to metal. 5, 6: film laminated to plastics. 7: film laminated to foam rubber

Bolta Products, Div. General Tire & Rubber Co.

Film laminated to plastics counter top

3. Decorative applications — color, versatility

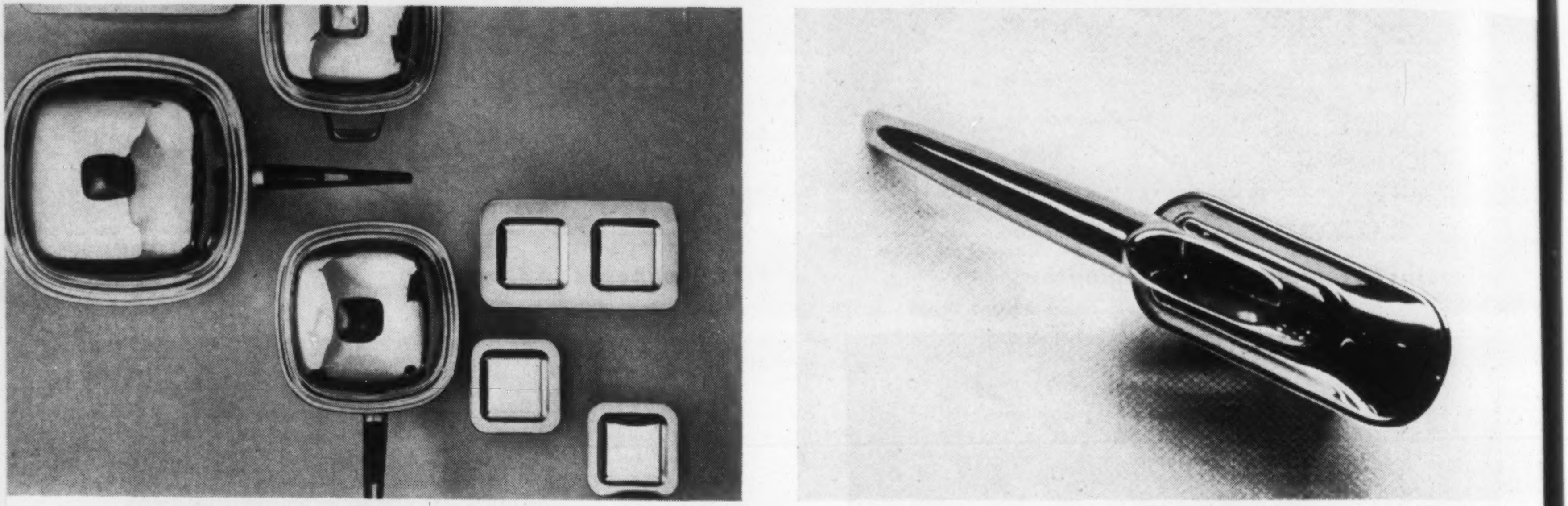
■ The fact that polyester film is a clear film that can be supplied with either a glossy or matte surface, and can be printed, metallized, dyed or decorated with colored adhesives, has resulted in a wide variety of decorative applications for the film.

Probably the most widely used decorative effects are obtained by using the film in combination with metal, either by vacuum metallizing the film or by laminating the film to metal foil by adhesive bonding. Metallizing the film, then bonding it, metal side down, to paper, metal, leather or plastics (such as vinyls), provides many styling effects. Such laminates can be embossed, fabricated or tailored. They are used for applications such as automobile, train and airplane interiors; furniture, upholstery, shoes, handbags, billfolds, belts, compacts and cigarette cases. Since the laminate is constructed so that the polyester film is on the exposed side, the metal film and the backing material are protected from scuff marks, scratches, and chemical attack or weathering. When applied to leather, the film provides protection against mildew. In addition to metallizing with such metals as aluminum, gold or silver, metallic effects can be obtained by using colored lacquers or pigmented adhesives in the bonding process.

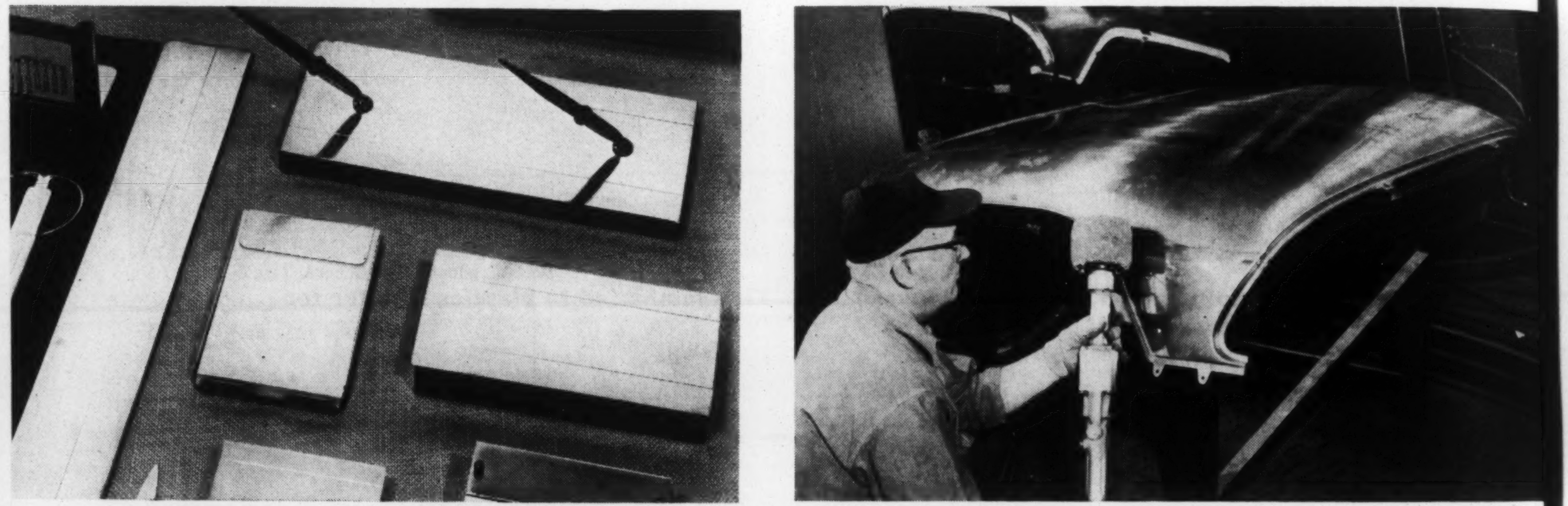
Decorative yarns can be made by slitting metallized film. Usual widths of such yarn range from 1/64 to 1/80 in., although it can be slit in widths narrow enough to provide workable deniers as low as 30. The yarn is strong enough to be twisted, quilted, woven or knitted into fabrics at normal operating speeds, and resulting fabrics withstand ironing temperatures. The yarn can be dyed with the same colors used on polyester fiber (Dacron) and can be cross dyed without discoloration.

Another interesting decorative effect can be obtained by dying polyester film. Colors available include amber, navy blue, black, bronze, blue and neutral gray. Such dyed films can also be metallized to provide other effects.

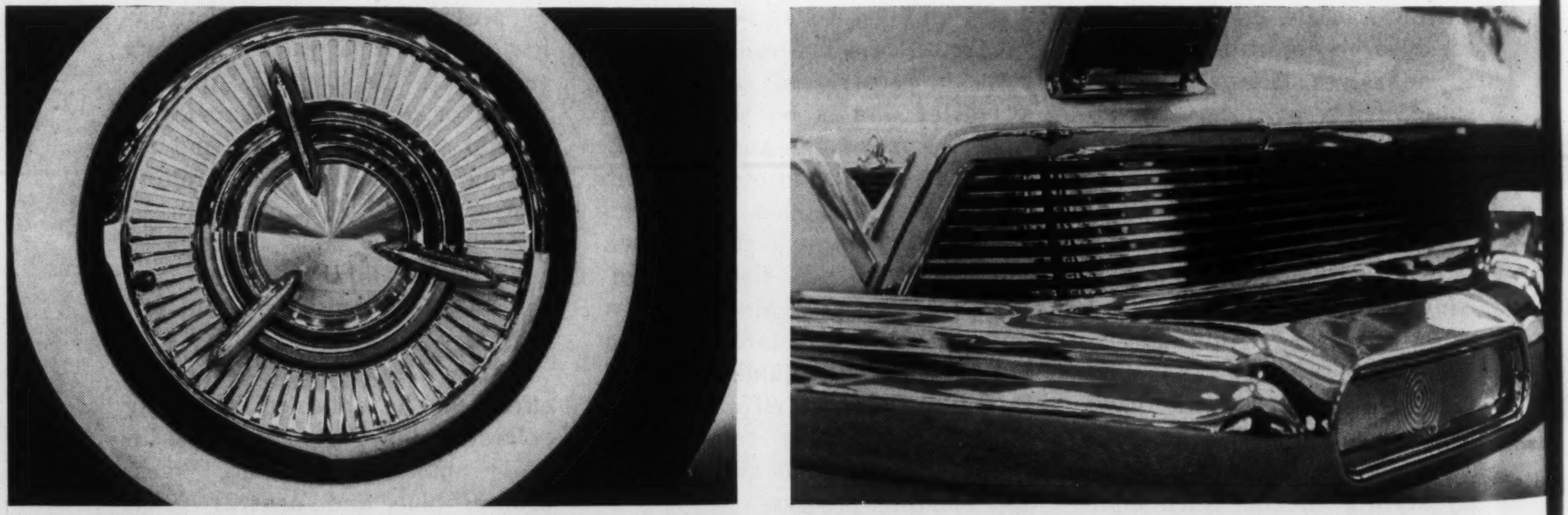
Selecting Mechanical Finishes



Smooth bright finish *(mirror finish) is widely used to enhance decorative appeal of a number of consumer products such as kitchenware, automobile trim and hardware.*



Satin finish, *applied by hand, is used to decorate desk set. Blended satin finish on built-up Cadillac roof is obtained by finishing entire assembly with abrasive belt after sides have been welded in place.*



Textured finish *on Pontiac wheel cover is obtained by polishing "spokes" and leaving recessed areas untouched; on Lincoln rear deck molding by filling recesses of horizontal ridges with enamel.*

for Stainless Steel

by **Richard E. Paret,** *Committee of Stainless Steel Producers, American Iron and Steel Institute*

HOW TO GET THEM

Type of Surface ↓	How Obtained	Initial Surface Required	Final Surface Appearance	Equipment Required	Typical Applications
Smooth Bright	Buffing	No. 2 strip finish, No. 2B or No. 4 sheet finish if not marred; otherwise, ground or polished surface with minor marks	Smooth, bright, highly reflective surface with barely perceptible abrasive marks. Mirror finish obtainable by using fine abrasives in final operation	Fabric buffs and fine abrasives used in conjunction with: polishing lathes; stand or swing grinders; or flexible shaft air or electric portable grinders	Highly reflective surface for household appliances, auto trim, sanitary equipment, jewelry, tableware
	Barrel finishing	Free of all but minor marks	Same as buffed finish	Equipment similar to barrel tumbling but imparts gentler motion. Stainless steel balls plus soap and water or similar media generally used. Fine abrasive used instead of balls for finest finish	Same as buffing but generally used for 1) small parts in large quantities, or 2) parts difficult to buff
Satin Semibright	Grinding and polishing	Rough finish or finish marred by fabrication	Smooth semibright surface containing fine scratches. More reflective than satin finish; less reflective than buffed or barrel finish	Stand or swing grinders; flexible shaft air or electric grinders; polishing lathes; fixed or hand abrasive belt, disk or sleeve machines	Architectural applications, cabinets, commercial kitchens and laboratory equipment, utensils; preparation for finer finishes
	Satin finishing	Uniform surface free of defects. No. 2 strip or No. 4 sheet finish (No. 2 sometimes used if not marred); otherwise, grind and polish to equivalent of No. 4	Smooth, lustrous semibright surface; not highly reflective	Same as for buffing but with tampico brushes instead of wheels; or with wicking wheels (sometimes buffs) and special abrasives	High quality surfaces without high reflectivity or for decorative contrast with brighter surfaces. Architectural equipment, tableware, appliances
Textured Semibright or Matte	Embossing and engraving	Polished, buffed or satin finish	Patterned finishes having wide variety of decorative effects	Embossing rolls or engraving equipment, often of pantograph type	Flatware, hollowware, plaques, tablets, nameplates, decorative panels. Recesses may be filled with enamel for contrast and decoration

■ A pleasing appearance, combined with high strength and corrosion resistance, have made stainless steel extremely popular in applications where both function and appearance are important. Although stainless steel can be finished by many nonmechanical techniques, such as electropolishing, enameling, etching and plating, mechanical finishes are most frequently used because of the quality and variety of finishes obtainable, and the ease with which they can be produced.

Using a mill finish

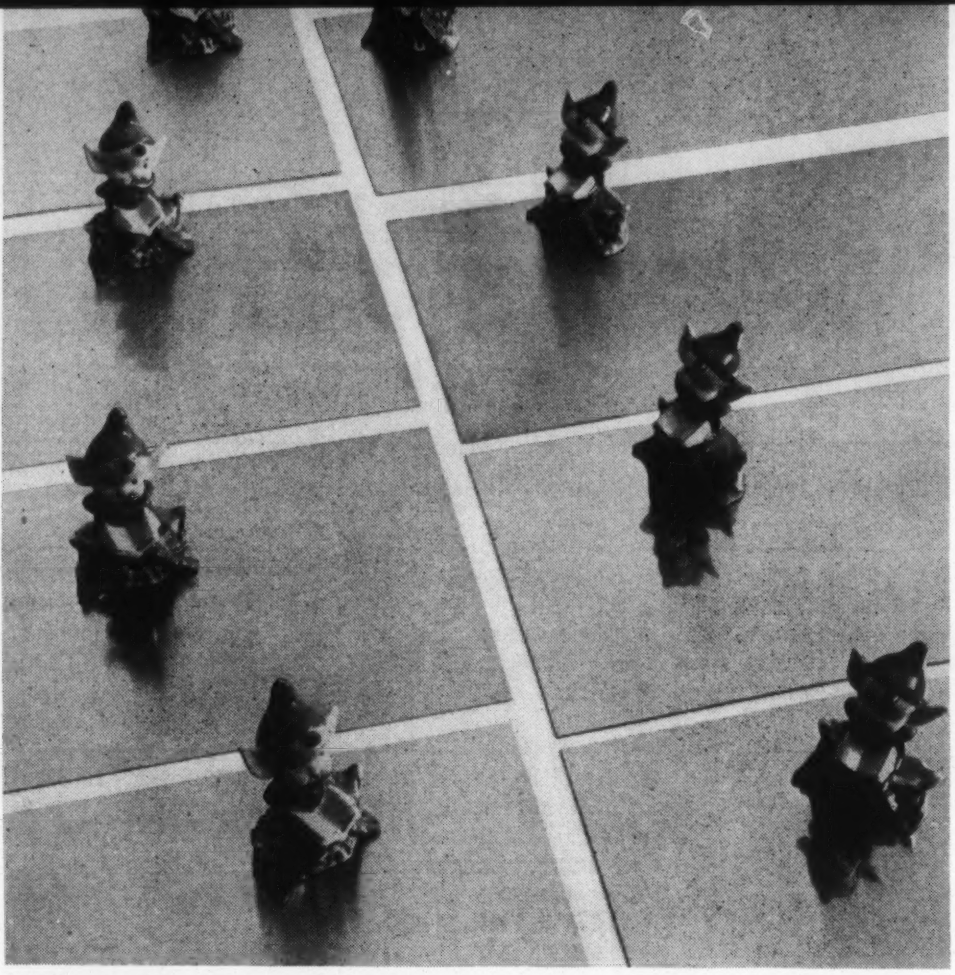
In many applications it is possible to eliminate in-plant finishing by selecting a standard mill finish. As shown in Table 1 and the photo on the next page, stainless steel sheet is available in a variety of standard finishes, ranging from the frosty white No. 1 finish to the mirror-bright No. 8 finish.

The No. 1 hot rolled, annealed and descaled finish is used where final appearance is not too important and where a mill polish is liable to be marred by processing operations such as annealing or machining. For example, a finish similar to No. 1 is often selected for parts that must be annealed between draws.

The No. 2D cold rolled and descaled finish is preferred where severe forming is to be followed by a final finishing operation. The surface holds lubricants satisfactorily and is well suited for deep drawing or spinning.

The No. 2B finish is similar to, but somewhat brighter than, the No. 2D finish, and is obtained by final light cold rolling between highly polished rolls. It is used where relatively light forming operations are to be followed by final finishing.

No. 4, 6, 7 and 8 mill finishes are obtained by polishing, brushing or buffing, and are intended for use where little surface damage is expected during fabrication. They can be used in applications



***Reflectivity** of various finishes can be compared by noting difference in reflections cast by figurines. Finishes on left side (from top to bottom) are No. 1, 2D, 2B, and 3; finishes on right side (top to bottom) are No. 4, 6, 7 and 8.*

TABLE 1—AVAILABLE MILL FINISHES FOR STAINLESS STEEL SHEET

Finish ↓	How Obtained	Surface Appearance	Used as Final Finish for . . .	Can Be Used Before Fabrication When . . .
No. 1	Hot rolling, annealing and descaling	Frosty white	High temperature or industrial applications	Appearance not important or when surface will be marred, as in annealing
No. 2D	Cold rolling and descaling	Similar to No. 1, but brighter	Industrial applications	Severe drawing is to be followed by polishing
No. 2B	Cold rolling	Bright	Curtain walls; industrial, commercial and transportation equipment	Light forming is to be followed by polishing
No. 3	Polishing	Bright	Not generally used as final finish	A semifinished surface is required for final polishing after fabrication
No. 4	Polishing	Bright, good luster	Most commonly used finish: architectural trim; restaurant, kitchen and sanitary equipment	Forming operations will not mar surface
No. 6	Tampico brushing	Soft, satiny	Decoration without high reflectivity	Forming operations will not mar surface
No. 7	Polishing and buffing	High luster	Decoration	Forming operations will not mar surface
No. 8	Polishing and buffing	Mirror finish	Decoration or a reflective surface	Forming operations will not mar surface

where localized forming, welding or light stamping are required, as in some kitchen and dairy equipment and automobile trim.

In addition to these sheet finishes, two finishes are available for stainless steel strip: a No. 1 finish that is similar to a No. 2D sheet finish, and a No. 2 finish that is also comparable to, but often brighter than, a 2B sheet finish. These finishes are widely used for automobile trim without subsequent polishing. Finishes available on other mill forms, such as bars, tubes and plates, are roughly comparable to those obtainable on sheet forms, and range from hot rolled surfaces to mirror polishes.

Suitable precautions should be taken to prevent scratching or marring of finished surfaces during fabrication. A number of protective coatings can be specified for application by the mill. Some commonly used shop methods include the insertion of paper between sheets or parts, and spraying of surfaces with peelable rubber latex or plastics coatings. Careful attention to lubrication during forming can also prevent surface damage and reduce finishing costs.

Simulating a mill finish

The No. 4 mill polish has proved to be the most popular finish for stainless steel parts. Table 2 describes the operations required to obtain this finish. The information is offered as a guide only; practice and experience will show how variations can be tolerated. Preliminary operations can often be eliminated, depending on the condition of the original surface.

Final hand finishing is useful for polishing large areas or for finishing welded areas so that they match adjoining surfaces. Welded areas can be obscured by blending polishing lines with a 150-180 abrasive cloth that is soaked in oil and mounted on a block. In all cases a lubricant should be used for final polishing.

Recommended operations for obtaining finishes equivalent to the high mill polishes, No. 6, 7 and 8, are contained in Table 3.

As shown, two buffing operations—cutting and color buffing—are required to obtain a No. 7 or 8 finish after polishing. The color buffing operation is comparatively short and is continued only until the true color of the metal is brought out. Neither buffing operation can be expected to remove any surface imperfections or heavy marks inflicted during polishing.

Selecting wheels and abrasives

Grinding—Solid wheels backed with hard rubber or bakelite are preferred for rough grinding. Vitrified wheels have a tendency to load up and cause overheating—a condition that can cause warping and heat tint. In severe cases the high heat generated during grinding can affect the temper of heat treated parts and even cause carbide precipitation in the austenitic chromium-nickel grades of stainless steel. In all cases manufacturers' recommendations for wheel speeds should be followed.

Polishing—Polishing is similar to grinding in that both operations are designed to remove excess metal and surface imperfections. The processes are distinguished chiefly by the severity of their cutting action—polishing being less severe and utilizing softer wheels, finer abrasives and some form of lubricant.

Fabric polishing wheels are available in a number of materials and types. Cloth wheels, made of fine count unbleached muslin, are the most commonly used. Wheels disks can be loose, glued or sewed, depending on the stiffness required; wheels of high stiffness provide the fastest cutting action. Also used are compress wheels consisting of segments of canvas, felt or leather. These wheels can be shaped to fit the contour of

TABLE 2—HOW TO OBTAIN A NO. 4 FINISH

Operation ⬇	Remarks	Wheel[a]	Abrasive	Grit[b]	Lubricant	Speed
1. Rough Grind	Starting operation for rough weld beads. Required only for very rough work	Rubber or bakelite—bonded	Aluminum oxide or silicon carbide	20-60	Dry	5-6000
2. Final Grind	Starting operation for heavy sheet or plate, hot rolled finishes or light welds	Rubber or bakelite—bonded	Aluminum oxide or silicon carbide	60-80	Dry	5-6000
3. Rough Polish[c]	Starting operation for cold rolled sheet or strip	Cloth	Aluminum oxide or silicon carbide	80-100	Polishing tallow or grease stick	7500
4. Final Polish	Gives No. 4 mill finish	Cloth	Aluminum oxide or silicon carbide	120-150	Polishing tallow or grease stick	7500

[a] Belts may also be used where shape permits. In general, same grit specifications are applicable.

[b] Grit used depends upon quality of finish or grit used in prior operation. Grit should be increased about 20 to 40 numbers for each operation.

[c] No. 3 finish can be obtained after this operation by final polishing with 100 grit belt or wheel.

TABLE 3—HOW TO DEVELOP A HIGHER FINISH FROM A NO. 4 MILL FINISH

Finish Desired ⬇	Operation	Wheel	Abrasive	Grit No.	Lubricant	Speed, sfpm	Remarks
No. 6	Brushing........	Tampico or similar brush	Powdered pumice with oil applied as paste	—	—	1-5000	Finish varies with abrasive and wheel speed
No. 7	1. Polishing........	Cloth	Aluminum oxide or silicon carbide	180	Tallow or grease stick	7500	May be followed by polishing with No. 220-240 grit
	2. Buffing (cutting)..	Bias type or sewed piece buff	Cutting compound	—	Cutting compound is supplied in stick or cake with lubricant	8-10,000	Cutting compounds must be iron-free
	3. Buffing (coloring).	Loose disk or bias type	Coloring compound	—	Same as above	8-10,000	—
No. 8	1. Polishing........	Cloth	Aluminum oxide or silicon carbide	180	Tallow or grease stick	7500	—
	2. Polishing........	Cloth	Aluminum oxide or silicon carbide	240-320	Tallow or grease stick	7500	—
	3. Buffing (cutting)..	Same as for No. 7 finish					
	4. Buffing (coloring).	Same as for No. 7 finish					

parts and are available in varying degrees of stiffness depending on the material used.

Abrasives used for grinding and polishing should be free of iron. Aluminum oxide is generally preferred for stainless steel; however, silicon carbide is also used occasionally.

To prevent overheating, long strokes and carefully controlled pressures should be used during grinding and polishing. High wheel pressures do little to increase cutting action, which is largely dependent on wheel speed, stiffness and the abrasive used. Thin, flat sheets should be adequately backed up to prevent warping.

Buffing—Buffing wheels should be made from a high count muslin. Sewed buffs can be used for the cutting operation. For color buffing, however, buffs made up with spacers between sections provide greater softness and ventilation and prevent overheating at high speeds. Good ventilation is also provided by bias-type buffs made up of corrugated cloth sections. String wheels are often used where more flexibility is needed.

Abrasives used for buffing are similar to those used for grinding and polishing in that they are iron-free and usually contain aluminum oxide. Green chromic oxide is sometimes used to obtain a mirror finish.

Barrel finishes

Barrel finishing is uniquely suited for deburring and brightening small parts in large quantities and for applying a bright finish to parts that are difficult to buff. The process is widely used for finishing such stainless steel parts as pen points, eyelets and grommets.

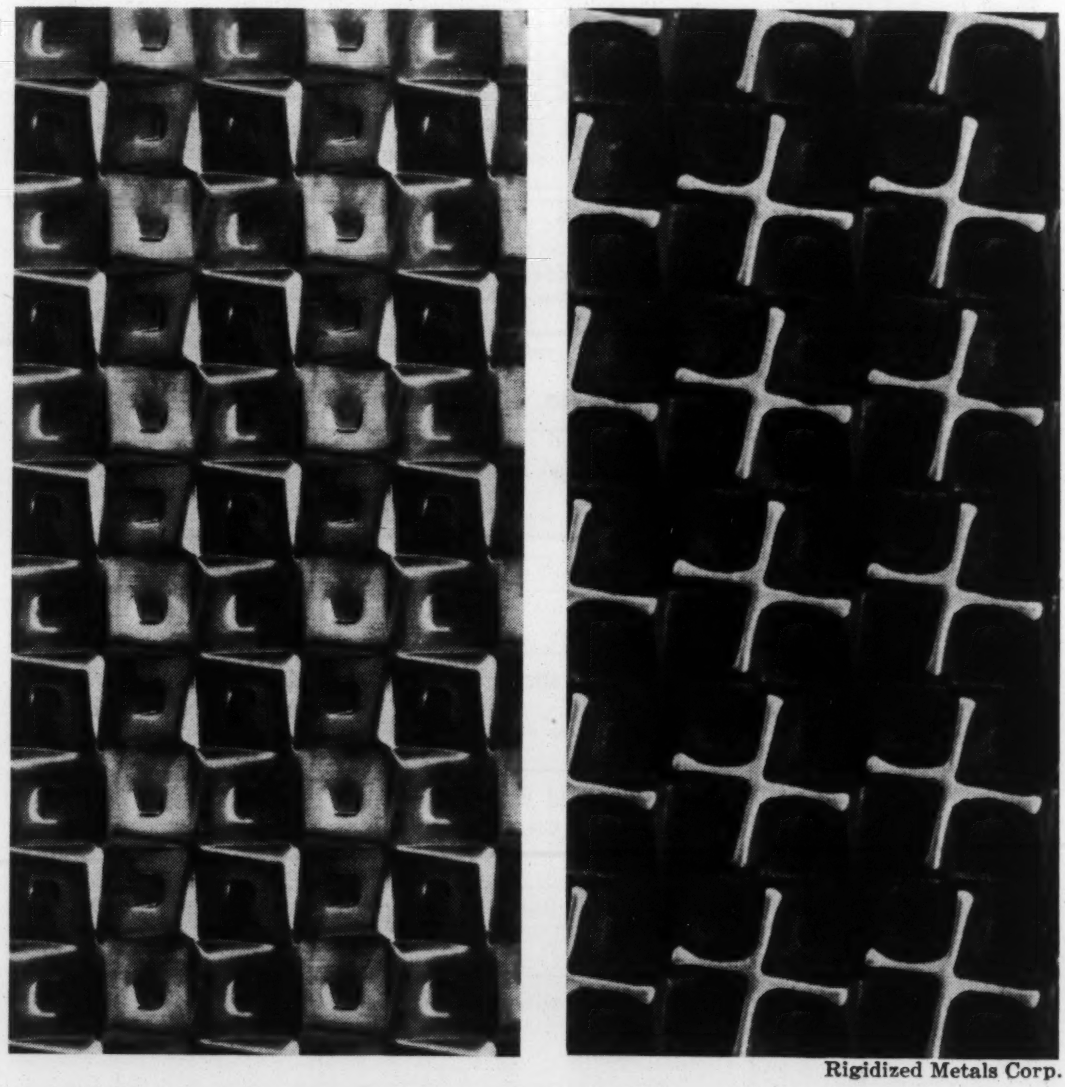
Two types of barrel finishing methods are available: deburring and ball burnishing or bright finishing. Granite chips are most commonly used for burr removal, although aluminum oxide, carborundum and sharp silica sand are also used. A typical work load consists of three or five parts of tumbling material (by volume) to one part of work, plus enough water and soap to cover the work. Total work load usually amounts to 50-60% of the barrel's capacity.

Ball burnishing is usually used to bright finish parts after they have been deburred. If parts do not require removal of excess metal, they can be ball burnished without prior finishing. Burnishing media usually consist of stainless steel balls, but cones, disks and pins can also be used. The work load generally contains two parts media to one part work, plus water and soap, and usually occupies 50-60% of the barrel's volume. In some cases Vienna lime is substituted for soap to provide cutting action. Barrels are usually rotated from 1 to 4 hr, depending on the nature of the part and the finish desired.

Textured finishes

A wide variety of textured patterns can be produced in stainless steel sheet by passing the metal between engraved rolls. Aside from their decorative effect, these finishes increase the rigidity of flat panels. In addition, the mechanical properties of austenitic grades are increased by work hardening during rolling.

Two-tone decorative effects can be obtained by combining the luster of steel with the color of an organic or porcelain enamel. Interesting effects (see photos) are produced by applying the enamel to the entire surface and 1) wiping the enamel off the high spots before baking or firing, or 2) polishing off the high spots after baking or firing.



Rigidized Metals Corp.

These textures are the same but . . .

. . . panel on left is untouched, whereas panel on right has been blackened over-all, then polished to accent high spots—an outstanding example of what can be done with textured finishes.

Photos courtesy International Nickel Co.

***Turbine blades** produced from Inconel 700 can operate at temperatures up to 1700 F.*

New Nickel Alloys for High Temperature Service

Modification of existing nickel-chromium and nickel-chromium-iron alloys has resulted in new alloys with improved high temperature characteristics. Here are data on five of them.

by Randolph P. Dominic

■ Special combinations of properties required to meet specific engine and airframe requirements are being met by modifications of existing alloys. Most of the work involves alloys of high nickel content, such as modifications of Inconel and Incoloy. They include Inconel 700, 702 and 713C and Incoloy T and 901.

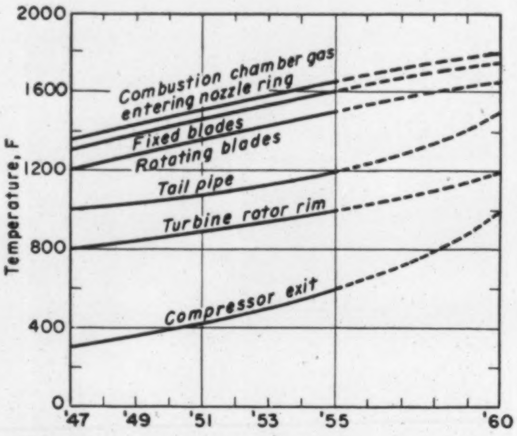
The Inconels

All of the new Inconels have a common characteristic. A large part of the improvement in their high temperature strength results from age hardening characteristics imparted by the addition of aluminum and titanium. A high temperature solution treatment followed by aging at a lower temperature hardens the alloy by precipitation of a dispersed phase. Unlike conventional age hardenable alloys, however, these aluminum-titanium modified Inconels have reversible age hardening characteristics. No serious damage results if the materials are subjected to temperatures some-

NOMINAL COMPOSITIONS OF THE ALLOYS

Alloy	C	Mn	Fe	Ni	Cr	Al	Ti	Co	Mo	Cb+Ta
Inconel	0.03	0.30	7.0	75.0	15.0	—	—	—	—	—
Inconel W	0.04	0.70	7.0	74.0	14.5	0.6	2.4	—	—	—
Inconel X	0.04	0.50	7.0	73.0	14.5	0.7	2.5	—	—	1.0
Inconel 700	0.10	0.06	1.0	46.0	15.0	3.0	2.0	29.0	3.0	—
Inconel 702	0.02	0.10	0.35	80.0	15.0	3.0	0.5	—	—	—
Incoloy	0.04	1.0	Bal	33.0	20.0	—	—	—	—	—
Incoloy T	0.04	1.0	Bal	33.0	20.0	—	1.0	—	—	—
Incoloy 901	—	—	Bal	42.0	12.0	—	2.5	—	6.0	—
Nimonic 75	0.11	0.50	1.0	77.0	20.0	—	—	—	—	—
Inconel 713C (cast)	<0.20	1.0	<5.0	Bal	12.5	6.0	0.75	—	4.5	2.0

what above the age hardening temperature, unless heating plus stress causes excessive creep deformation. When the metal is overheated some of the dispersed phase returns to solution and there is a corresponding reduction in strength. However, when temperature is reduced, the hardening component reprecipitates and original hardness is restored. In conventional age hardenable alloys, appreciable exposure to temperatures above the age hardening temperature causes permanent softening of the alloy; hardness can be restored only by reheating to the solution temperature and re-aging.



***Temperature trends** in aircraft jet engines.*

Some of the Inconels are used as aircraft gas turbine materials and as sheet materials for other aircraft and industrial components. When used as turbine blades, the alloys are given a high temperature solution treatment before aging. This treatment increases their rupture strength.

High temperature solution treatment of sheet is impractical. Cooling from the required temperature causes buckling that must be rectified by cold rolling or stretching. This cold working substantially reduces rupture strength; for example, as little as 0.5% permanent strain introduced at room temperature completely cancels the improvement in strength resulting from solution treatment of Inconel X sheet. A similar loss of strength would result from the cold forming of solution treated sheet into a useful product.

Another factor making it impractical to supply sheet material in solution treated condition is grain growth resulting from long exposure at high temperature. A rough surface condition ("orange peel") may result if such material is deep drawn or severely bent.

Because of these factors, In-

***Tail cones** require materials such as Inconel 702 that are resistant to high temperature corrosion.*

conel sheet alloys are usually supplied in the annealed condition. Typical differences in rupture strength between solution treated and annealed material are indicated in Fig 1.

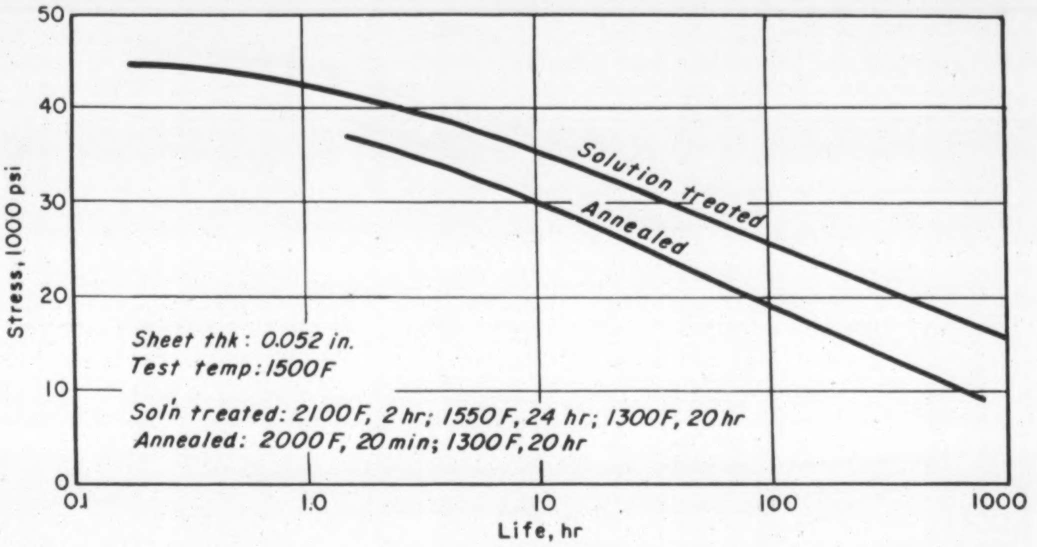


Fig 1—*Rupture strength of Inconel X is affected by method of heat treatment.*

Special short time aging treatments have been developed to improve the room temperature properties of sheet alloys. The conventional aging treatment is 20 hr at 1300 F; by raising the temperature to 1400 F, the time for aging sheet materials can be cut to 1 hr without seriously reducing strength. For example, aging Inconel X sheet 1 hr at 1400 F produces a tensile strength of 166,000 psi, compared with 178,000 psi produced by aging 20 hr at 1300 F. This short time treatment is now being used widely because it is more practical and more economical for sheet than the conventional method used with more massive forms.

The Incoloys

Alloys in the Incoloy group have nickel, chromium and iron as the major constituents and thus differ from the Inconels that are basically nickel-chromium. Nickel content of the Incoloys generally ranges from 30 to 35% whereas most Inconels contain more than 70% nickel.

In the new Incoloys developed to meet more stringent stress and temperature requirements, the basic composition has been modified by the addition of titanium and molybdenum. Addition of titanium produces a sheet alloy of moderate strength whereas addition of titanium and molybdenum produces an alloy that can be age hardened. In sheet form this alloy, Incoloy 901, can be hardened by aging 2 hr at 1400 F, the short time aging treatment being used for the reasons discussed previously.

Inconel 700

Inconel 700, age hardenable nickel-cobalt-chromium alloy, was developed to meet stress and temperature conditions beyond the range of Inconel X. Short time tensile and stress rupture properties of this alloy are given in Fig 2 and 3.

Recent work on Inconel 700 shows that modifications in heat treatment, though sacrificing some high temperature rupture strength, are useful in improving fatigue strength. Normal heat treatment — solution treatment at 2150 F followed by aging at 1600 F — results in a fatigue strength of 45,000 psi at 1200 F. Aging of hot rolled material directly at 1400 F increases the fatigue strength to about 90,000 psi.

Inconel 700 is useful for turbine blades that operate at temperatures up to 1700 F, and may serve at higher temperatures under certain conditions. This alloy extends the operating temperature range 100° F above that of Inconel X for the same rupture strength.

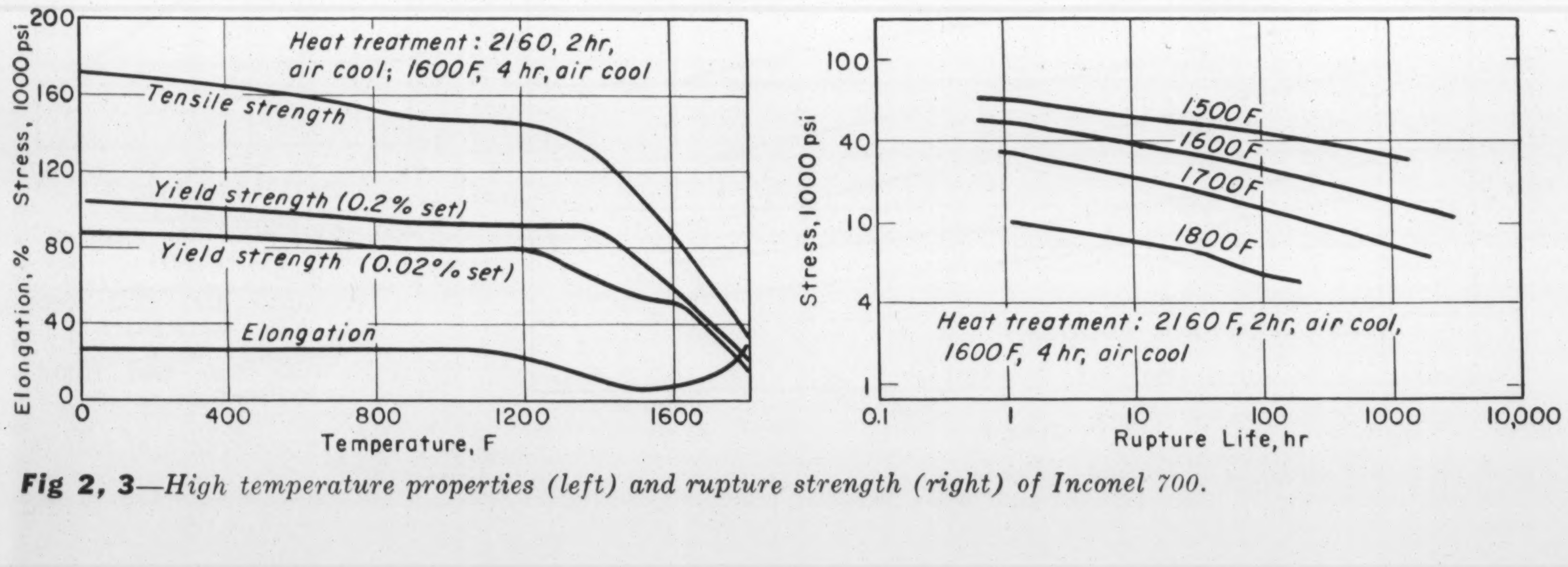


Fig 2, 3—*High temperature properties (left) and rupture strength (right) of Inconel 700.*

Inconel 702

Inconel 702 nickel-chromium alloy was developed to meet the need for a metal of moderate strength with exceptional oxidation resistance at elevated temperatures. Comparison of the oxidation characteristics of several metals in Fig 4 shows that Inconel 702 has excellent oxidation resistance in the 2000 to 2400 F range. The 702 alloy, for example, loses only 4% of its cross section in 100-hr exposure at 2200 F — conditions under which cobalt-base alloys are completely oxidized.

Short time tensile properties (Fig 5) and stress rupture properites (Fig 6) give an indication of the effect of temperature on the mechanical properties of this material.

Inconel 702 is a logical choice for applications in which oxidation resistance is critical and light loads are encountered. These include combustion liners and the transition pieces that direct the flow of hot gases from the combustion chamber to the turbine wheel in a jet engine.

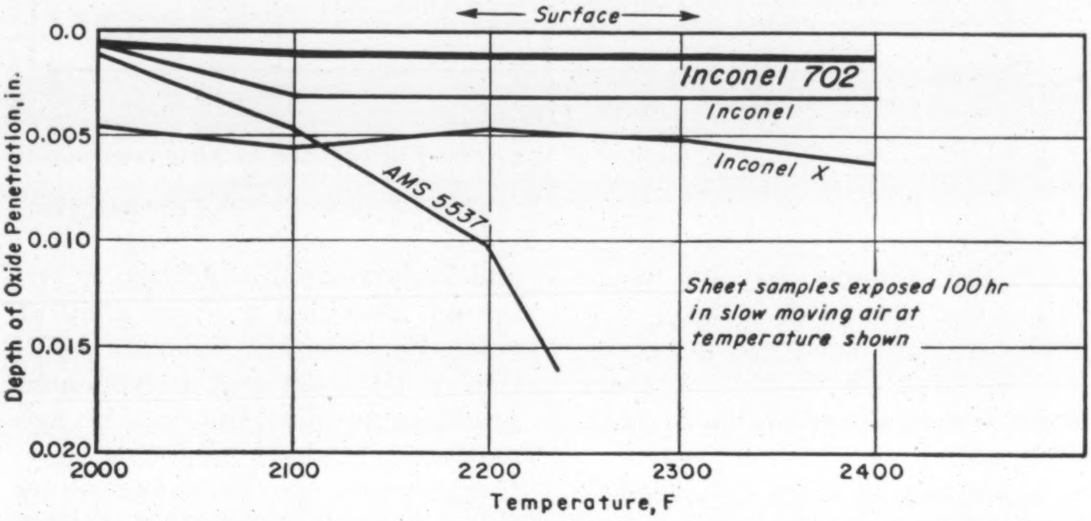


Fig 4—*Oxidation rates of a number of metals show the excellent resistance of Inconel 702 in the 2000 to 2400 F range.*

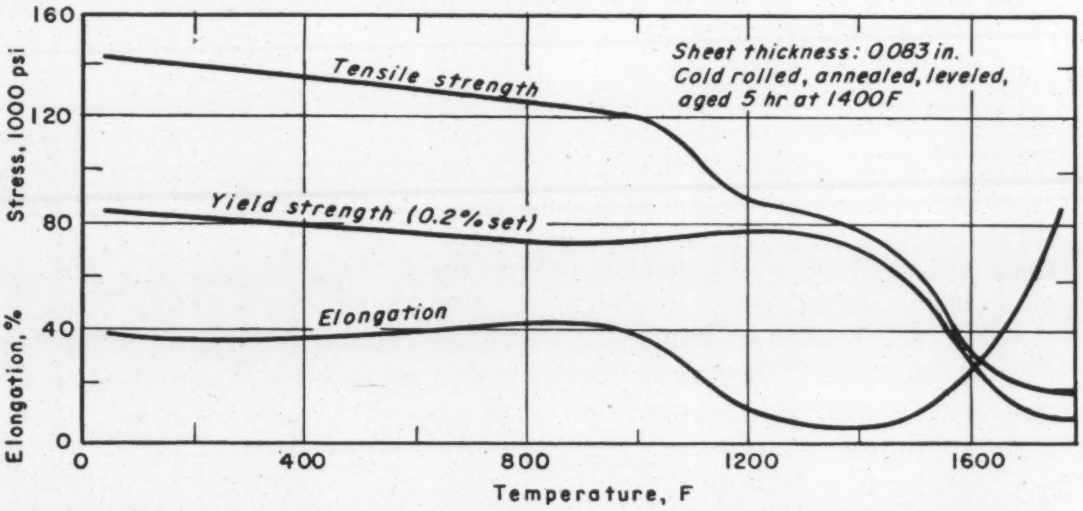


Fig 5—*Elevated temperature mechanical properties of Inconel 702 sheet.*

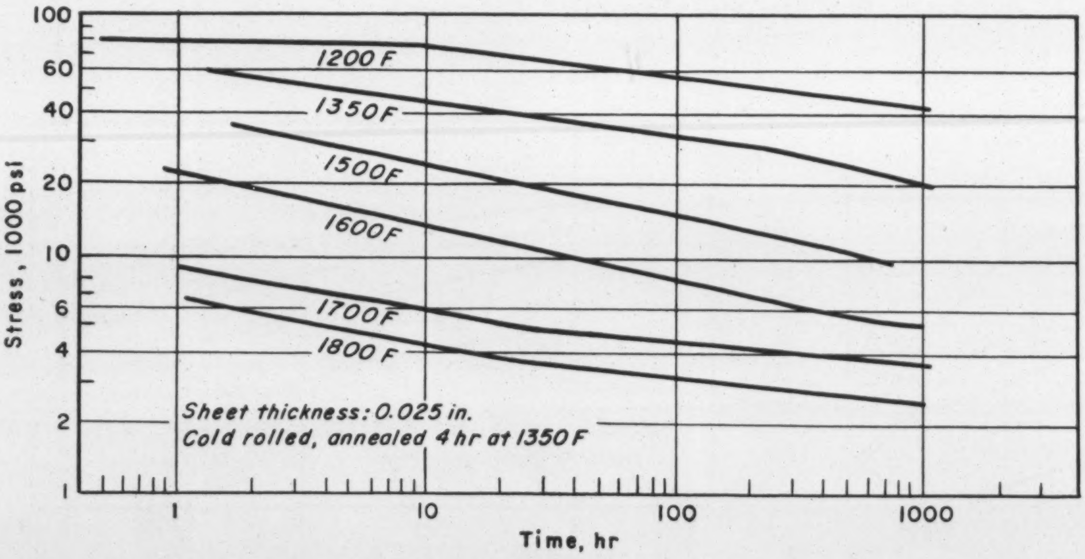


Fig 6—*Rupture strength of Inconel 702 sheet.*

Inconel 713C

Inconel 713C is the only alloy in the group that is used in cast form. This alloy has outstanding rupture strength at 1700 F and excellent resistance to thermal fatigue. It is especially suited for turbine blade applications in engines of advanced design. Effects

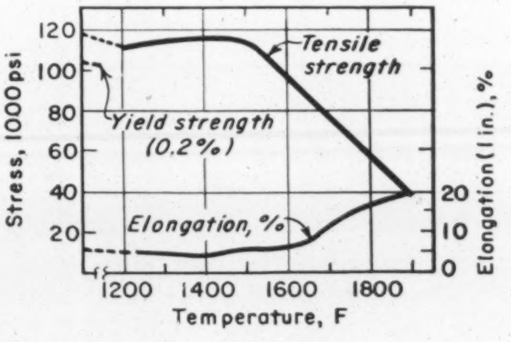


Fig 7 — *Elevated temperature mechanical properties of cast Inconel 713C.*

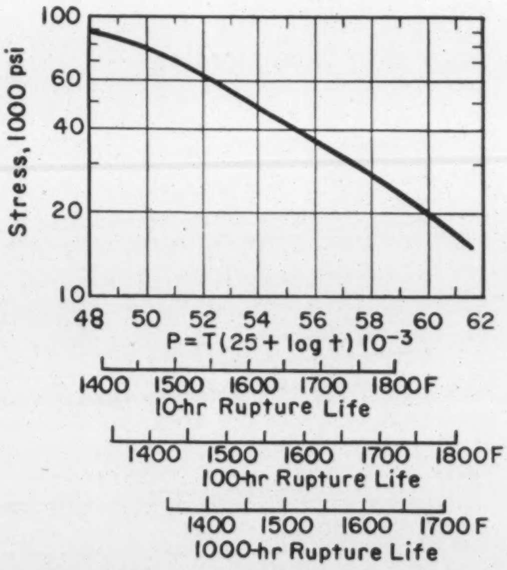


Fig 8—*Rupture strength of cast Inconel 713C.*

of temperature on short time tensile and rupture properties are given in Fig 7 and 8.

Resistance to thermal fatigue is indicated by results of a series of tests run on investment cast blades of Inconel 713C, in comparison with AMS-5382-B (25.5 chromium, 10.5 nickel and 7% tungsten), one of the better blade materials available at present. The materials were alternately heated to 1700 F by an oxyaceteylene flame and cooled by air blast, each cycle requiring 1 min. In this test, Inconel 713C averaged 877 cycles before appearance of the first crack; AMS-5382-B averaged 426.

Incoloy T

Incoly T is a moderately strengthened Incoloy alloy produced by adding about 1% titanium to the basic nickel-chromium-iron alloy. Currently, it is available only in sheet. Rupture data show that this alloy is not as strong as the new Inconel alloys (see Fig 9) but is somewhat superior to basic Inconel and Incoloy.

Incoloy T is used for combustion liners and other components where stresses are moderate and temperatures range up to about 1800 F.

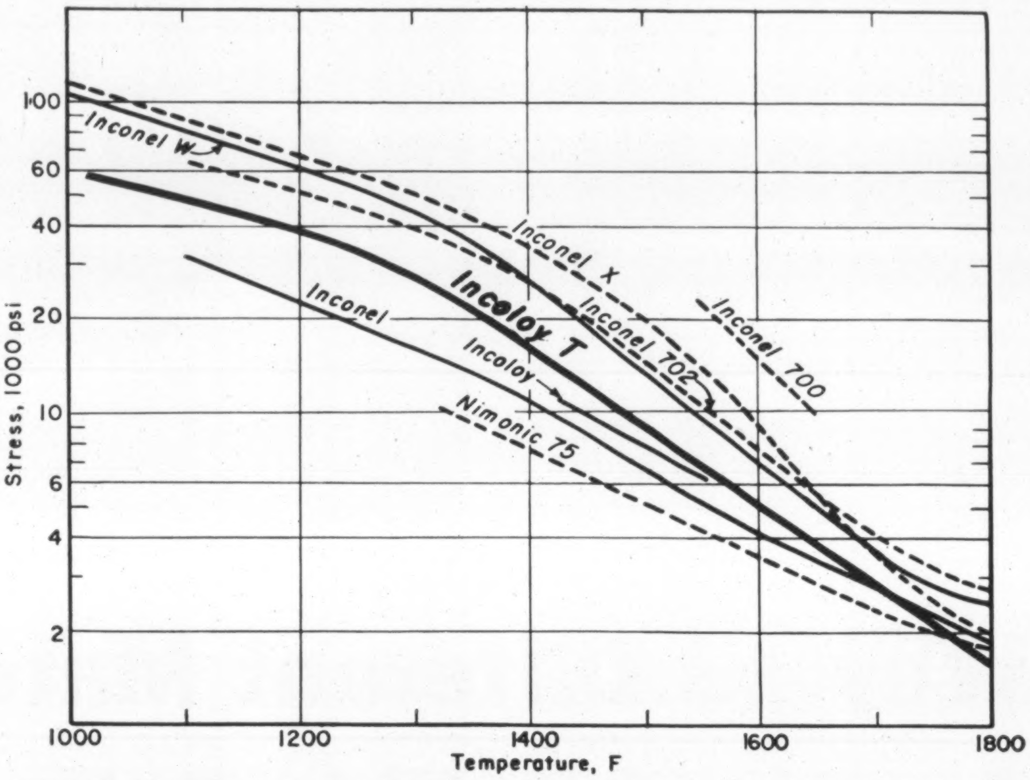


Fig 9—*Rupture strength of Incoloy T sheet is moderately higher than that of the basic Incoloy.*

Incoloy 901

Incoloy 901 was developed to match the mechanical properties of Inconel X at temperatures up to 1350 F. This is accomplished by increasing the nickel content of the basic Incoloy alloy to the 40 to 45% range and adding titanium and molybdenum.

The best high temperature rupture properties of Incoloy 901 are obtained by a high temperature solution treatment before aging. However, sheet is formed in the annealed condition and aged by a short time (2 hr) treatment at 1400 F. The properties of this alloy are given in Fig 10 and 11.

The major use of this alloy is in turbine disks. Inconel X meets the needs of engines now in production, but operating temperatures are not sufficiently high in most current engines to justify the use of this alloy for disks. The less expensive Incoloy 901 can replace Inconel X at temperatures up to 1350 F.

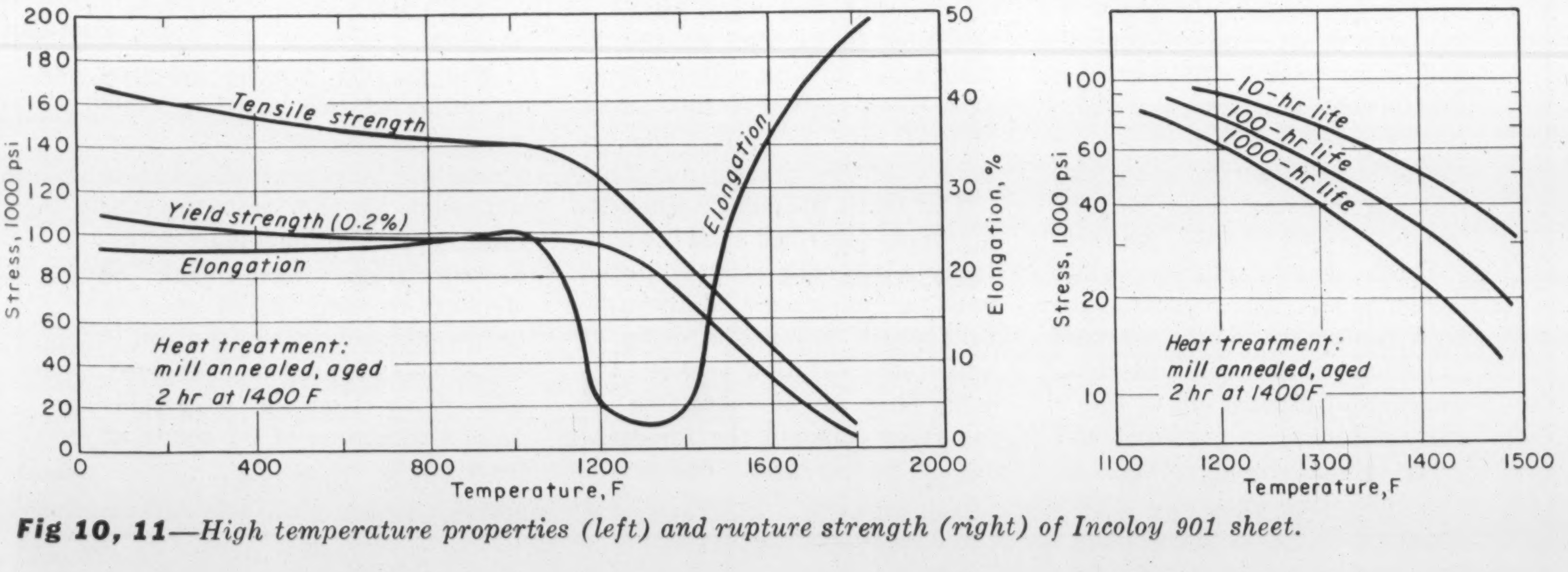
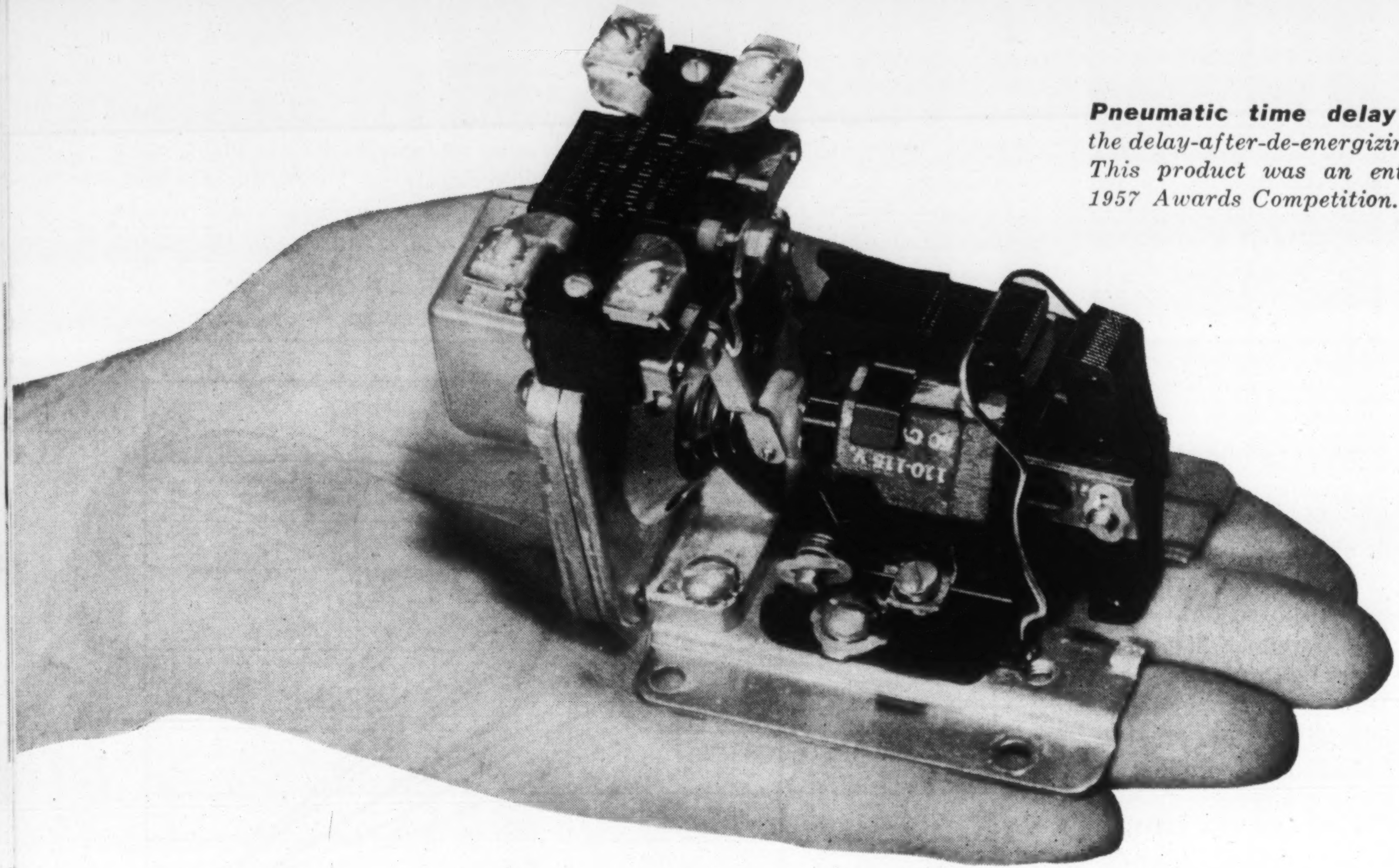


Fig 10, 11—*High temperature properties (left) and rupture strength (right) of Incoloy 901 sheet.*



Pneumatic time delay relay *in the delay-after-de-energizing position. This product was an entry in the 1957 Awards Competition.*

Why 13 Different Materials Are Used in This Relay

Here is a part-by-part analysis of the selection of materials for a time delay relay.

by C. A. Schaefer, H. C. Belling, R. F. Gottsacker and D. F. Grobe, *Square D Co.*

Time Delay Relay: What It Does

Automatic control circuits utilizing timing relays are required for many applications such as processing control, air conditioning control, machine tool control, and many others. Wherever a control sequence requires a short timing period between successive operations or functions, a pneumatic time delay relay may be the best answer to the problem.

These devices may be called on to handle other control relays, contactors, motor starters and other equipment in alternating current circuits up to 600 v max, although the present trend is for control circuit voltages of 110 v or less. Timing must be consistent within not more than ± 15%, under temperature conditions that may vary from below zero to as high as 150 F. Variations in line voltage from 15% below normal to 10% above normal must not affect the accuracy of the timing function.

The small pneumatic time delay relay described here is essentially a magnetic relay equipped with a pneumatic diaphragm unit which provides a delay of adjustable duration between the energizing or de-energizing of the relay coil and the functioning of the contacts. The device is composed of three basic units: a pneumatic time delay mechanism, a two-circuit double-throw switch and an a.c. operating magnet.

The magnet can be mounted in either of two positions: one provides time-delay-after-energizing of the magnet coil before actuation of the contacts; the other provides time-delay-after-de-energizing. Restoration of contacts to their initial position is instantaneous when the coil is either de-energized or energized. The delay time is adjustable from a minimum of 0.2 sec to at least 1 min.

Time delay unit

Valve housing (1) and exhaust head (2)

Requirements: Encloses diaphragm assembly and needle valve. Exhaust head also serves for mounting the unit on base plate and for supporting the switch unit.

Material selected: Zinc die castings.

Reasons: Adaptability to molding complex shapes, rigidity, strength, and minimum amount of machining necessary.

Diaphragm (3)

Requirements:

1. Diaphragm flexes with each operation of the timer. Since it must be operated by a relatively weak spring, its flexibility must be substantially flat and must remain constant throughout any range of temperature (from -20 to + 150 F).
2. To make the release valve integral with the diaphragm, the diaphragm material must be soft and smooth enough to produce a tight seal with relatively low unit pressure.
3. Diaphragm must be capable of bonding to stiffening disk in outer portion with an airtight seal.
4. It must be moldable to produce valve surface at the center and sealing bead around the periphery for clamping between the two zinc die castings.

Material selected: Low cold-test silicone rubber.

Reasons:

1. Silicone rubber proved superior to two other materials tested (see Fig 1). No change in time was evident even at temperatures as low as -94 F.
2. The material possesses unusual stability, is highly resistant to aging in practically all atmospheres, and has a long service life.

Valve seat (4) and bushing (5)

Requirements: The valve seat, which threads onto the top end of the shaft, must function as the upper guide for the shaft. Galling and wear of the zinc die castings must be avoided.

Material selected: Molded nylon.

Reason: In order to avoid galling and wear of the zinc die castings, a nonmetallic material was judged desirable. Nylon proved ideal for the valve seat because it provides a smooth surface and an extremely low coefficient of friction. For these same reasons, a molded nylon bushing is pressed into the exhaust head casting to guide the shaft extending below the diaphragm.

Diaphragm button (6)

Requirements: Attaches to bottom end of shaft, engaging a pin at end of operating lever between its upper and lower flanges.

Material selected: Machined nylon.

Reasons:

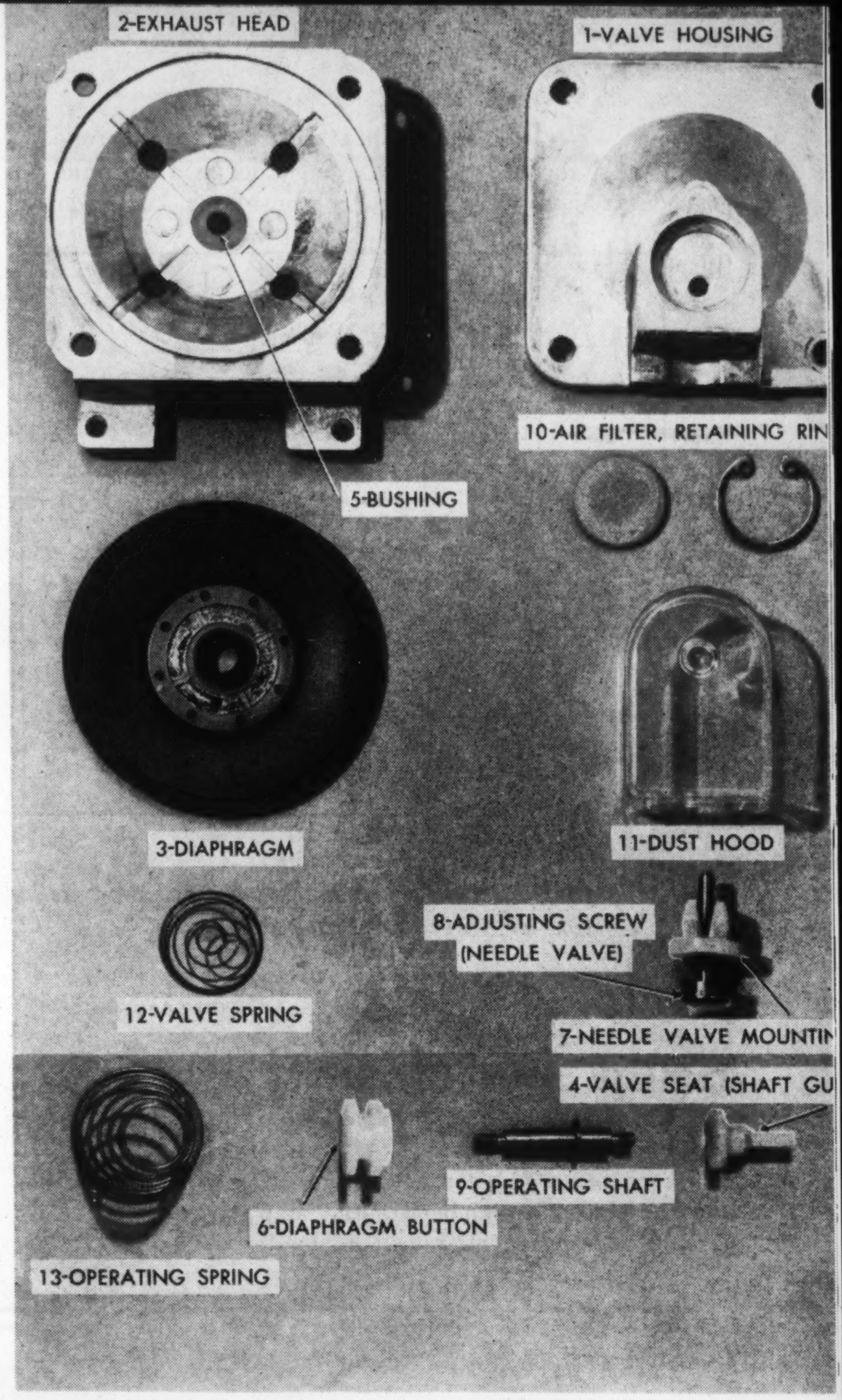
1. Spool-type part is machined from nylon rod to insure that no molding fin interferes with proper fit of lever pin. Low friction coefficient and antigalling properties of nylon allow part to withstand millions of blows from operating magnet without appreciable wear.
2. Nylon is relatively soft compared to the stainless steel operating shaft and contracts slightly after tapping, preventing the part from loosening up on the shaft in service. This effect obviates the need for lock washers or other locking means, and greatly facilitates assembly.

Needle valve mounting (7)

Requirements: Mounting must hold needle rigid yet allow it to be readily adjustable by hand. After adjustment, the needle must remain firmly in position.

Material selected: Molded nylon.

Reason: Nylon provides a smooth friction fit.



Components *of pneumatic time delay unit.*

Adjusting screw (8) and operating shaft (9)

Requirements: These parts must be corrosion resistant and free machining. A 32-microinch finish must be given to the accurately tapered end.

Material selected: Free machining 416 stainless steel.

Reasons: Excellent machinability, corrosion resistance.

Air filter (10)

Requirements: Must keep dust and dirt out of the needle valve and valve seat.

Material selected: Porous bronze, pressed and sintered by powder metallurgy. It is held in place by a Waldes retaining ring.

Reason: Porous bronze provides a good filter. If it becomes contaminated, however, it can be easily removed, cleaned and replaced.

Dust hood (11)

Requirements: Prevent unnecessary contamination of air filter by dust falling onto unit from above.

Material selected: Molded heat resistant polystyrene.

Reason: A drawn metal stamping and an aluminum impact extrusion were originally considered but required relatively high tooling cost. Injection molding of polystyrene costs less. In addition, a clear, transparent material makes it possible to observe condition of powdered bronze filter.

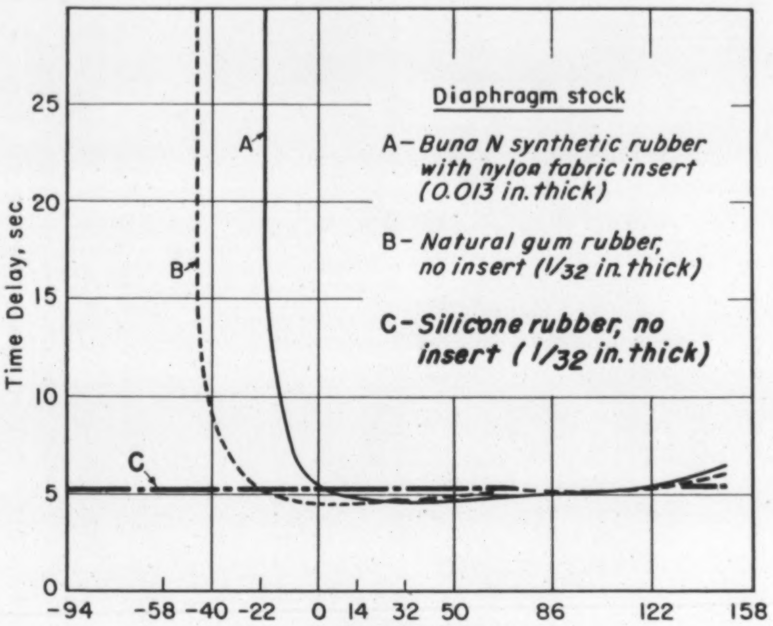


Fig 1—*Effect of ambient temperature on time delay characteristics of three diaphragm materials.*

Valve spring (12) and operating spring (13)

Requirements:

1. Both must be of conical type in order to provide stability and permit mounting in a space of minimum height.
2. Must be wound with graduated pitch to maintain low spring rate throughout their range of deflection.
3. Must resist ordinary atmospheric corrosion.

Materials selected: Copper-coated stainless steel spring wire and tin- or cadmium-coated music wire.

Reason: Experience had shown that fine wire springs of this shape cannot be economically plated, since they become almost hopelessly tangled in the process. Hence, 0.018-in stainless steel spring wire was specified for the valve spring. At the suggestion of the spring maker, the stainless steel was copper coated to prevent galling in the coiling process. For the heavier and more highly stressed operating spring, tin- or cadmium-coated music wire was specified, the precoating providing the necessary corrosion protection.

Snap switch unit

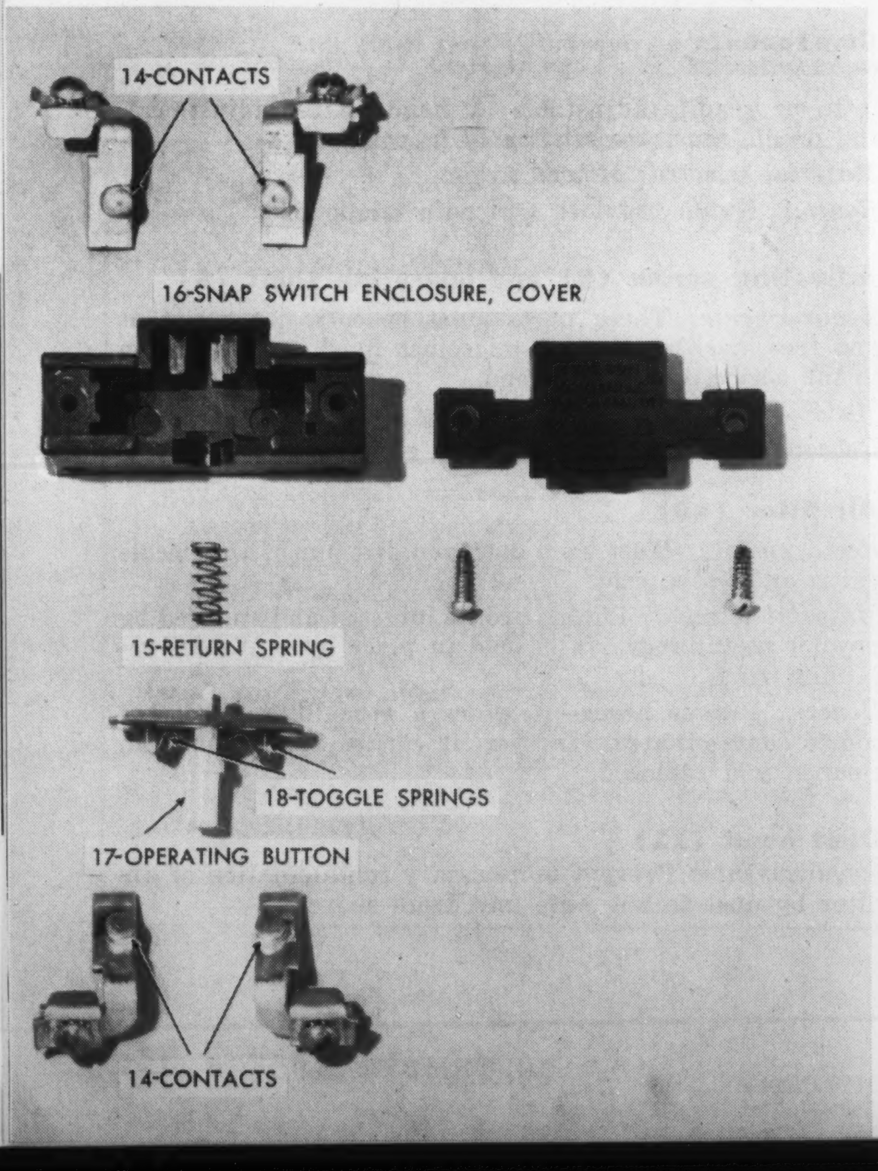
Contacts (14)

Requirements: The contacts, located on both the stationary and bridging members of the snap switch, must resist contact welding or sticking.

Material selected: Cadmium-oxide silver.

Reason: This material was found to have better resistance to contact welding and sticking than fine silver contacts normally used in similar applications. In this particular instance the material could be obtained with no increase in cost.

Components *of snap switch unit.*



Return spring (15)

Requirements: Must resist attack by nitric acid and other corrosive products sometimes formed within enclosed switches under certain operating conditions.

Material selected: Copper-coated 302 stainless steel.

Reason: Stainless steel will resist the corrosive products normally encountered. Copper coating is used as an aid in coiling and is not intended to furnish corrosion protection.

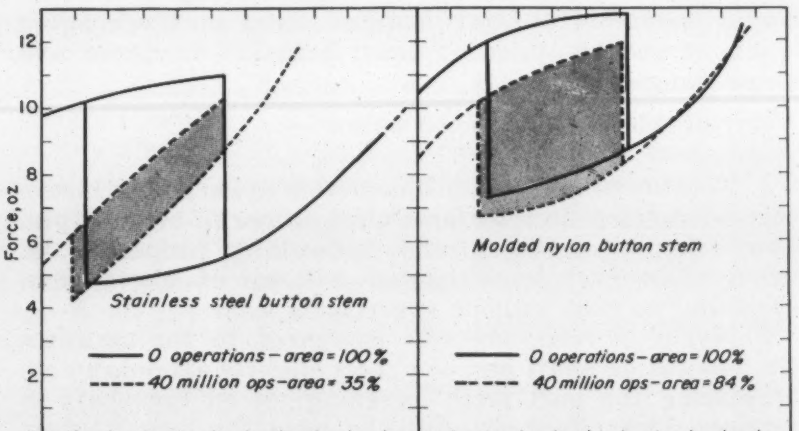


Fig 2—*Operating characteristics of snap switch compared for button stems of stainless steel and molded nylon.*

Snap switch enclosure and cover (16)

Requirements: Must have good impact strength, excellent dimensional stability, good resistance to carbon tracking, and good electrical properties.

Material selected: Electrical grade phenolic.

Reasons: Melamine was first considered for this application because of its excellent electrical properties. However, cost considerations and the difficulty of molding this material in automatic molding presses led to the selection of special grade phenolic.

Operating button (17)

Requirements: Wear resistance, good insulating properties, dimensional stability and low cost.

Material selected: Molded nylon.

Reasons:

1. In a previous design of a similar switch unit, the operating button was made of phenolic cemented to a stamped stainless steel stem. A series of tests proved nylon more suitable (see Fig 2) in its wearing qualities.
2. Walls could be extended around toggle spring slot to better contain toggle springs under high shock conditions. As a result, electrical clearances were increased.
3. Since parts can be produced in a single cavity mold, dimensional variation was eliminated. High uniformity permits operating characteristics of switch to be held wthin much closer limits than would be possible if some other material not lending itself to this particular fabricaion method were used.

Toggle springs (18)

Requirements: Because of the narrow limits on the operating force of the snap switch, the force exerted by the toggle springs must be held within close tolerances. Spring material must also have a high fatigue strength to provide long life.

Material selected: Precipitation hardening beryllium copper strip.

Reason: With conventional thin strip, springs must be overformed to allow for springback. Beryllium copper springs can be formed in accurate dies to final dimensions.

Magnet assembly

Magnet frame (19) and armature (20)

Requirements: Must be of laminated construction to avoid eddy currents.

Material selected: 3.5% silicon steel, 0.025 in. thick.

Reason: Although various grades of such steel are available, the material selected satisfied all of the requirements for cost, core loss, residual magnetism and die life.

Magnet coil (21)

Requirements: In addition to performing normal coil functions, the unit must act as a guide for the armature.

Material selected: Epoxy-impregnated copper wire.

Reason: When cured, the epoxy resin insures an accurately shaped coil with a hard, wear resisting surface which allows accurate confinement and centering by the outwardly formed lugs on the magnet frame sideplates.

Yoke (22)

Requirements: Supports and guides the armature assembly inside the molded coil. Must be nonmagnetic and of fairly high electrical resistance for operation in the magnetic field of the coil.

Material selected: Type 302 stainless steel cold rolled strip.

Reason: This material met all requirements.

Armature pivots (23)

Requirements: Used for hinged mounting of armature in yoke. Must be extremely wear resistant to withstand shock from impact of armature against magnet frame.

Material selected: Cold rolled steel, case hardened and nickel plated.

Reason: Experience has shown that this material is extremely wear resistant.

Springs (24, 25)

Requirements: Both the double torsion spring, which serves as a return spring, and the spring clip, which functions as the retainer for the magnet coil, must resist hydrogen embrittlement.

Material selected: Tin- or cadmium-coated music wire.

Reasons: Use of precoated wire not only obviates the need for plating the springs after forming, but also avoids the danger of hydrogen embrittlement (a serious cause of failure if plated springs are not properly heat treated after plating).

Retainers (26)

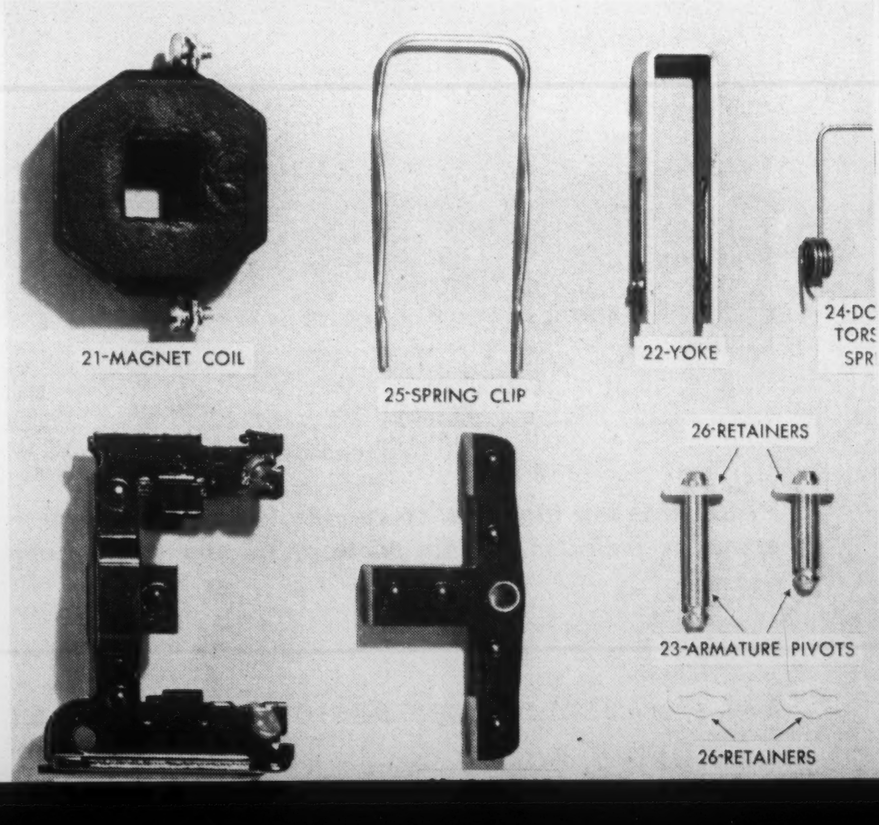
Requirements: Snap into grooves near the ends of the retaining pins, locking them into place. Must be resilient and strong.

Material selected: Nylon.

Reasons:

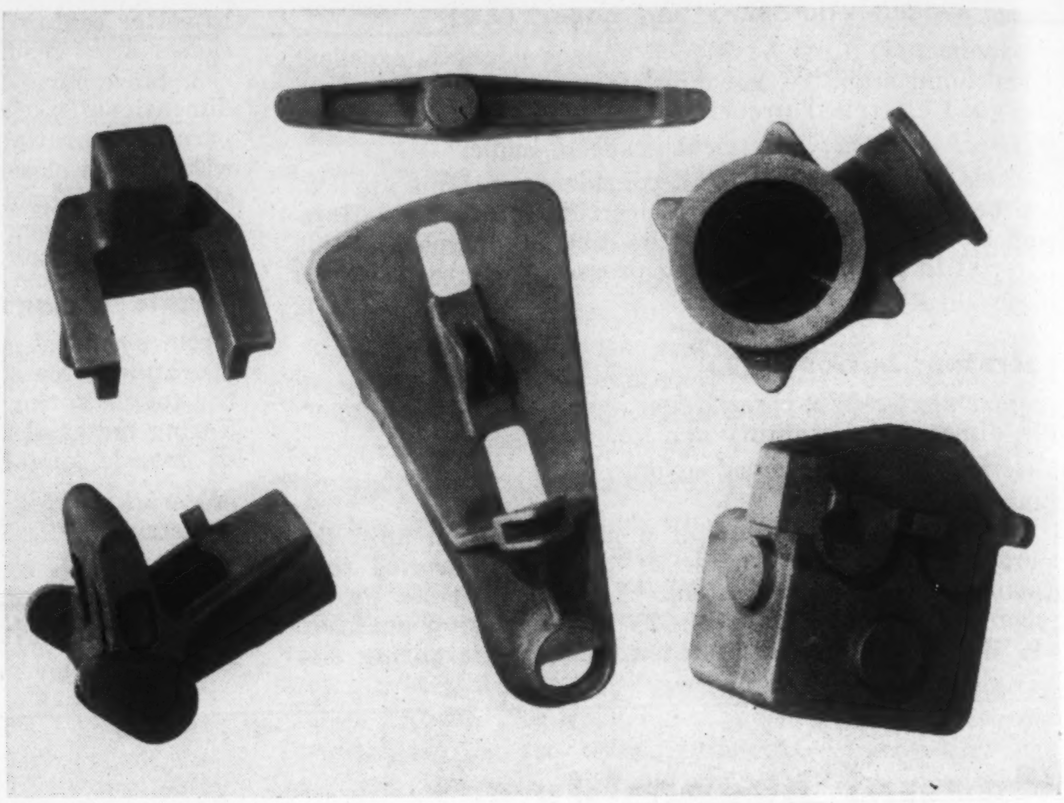
1. Nylon has proved successful in applications of this kind because of its resilience, toughness and wear resisting qualities.
2. Pins on which they are used are fabricated in a regular screw machine operation, and no costly drilling of cross-holes through the pins is required.
3. Metal-to-metal contact is eliminated

Components *of magnet assembly.*



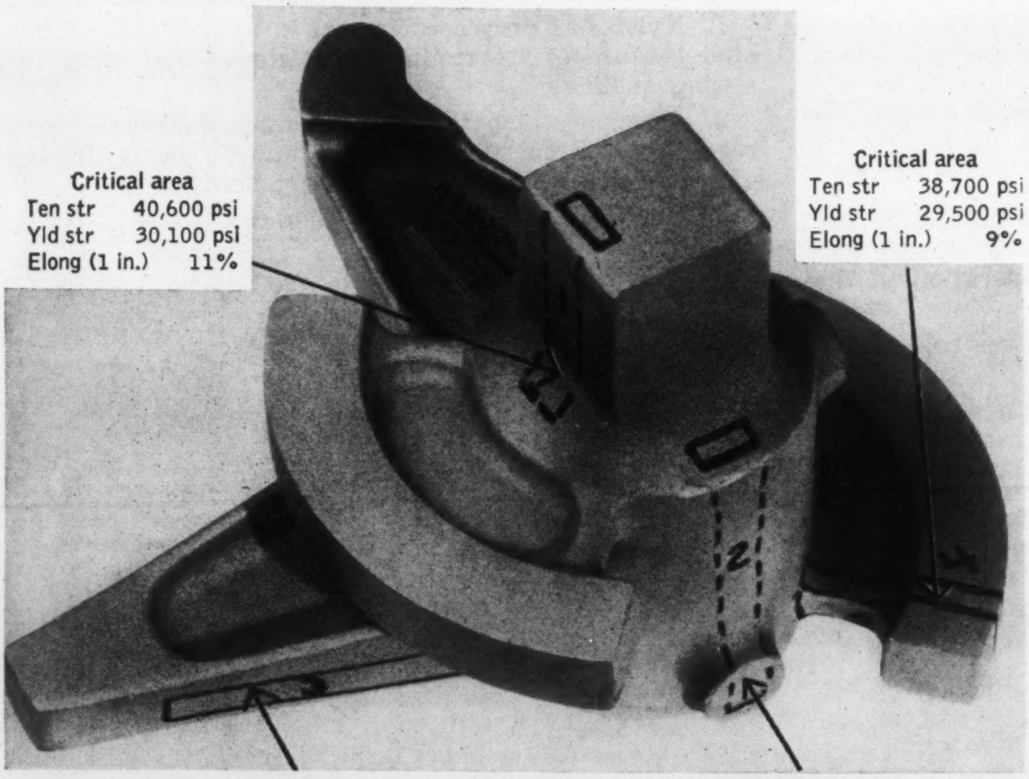
These aircraft parts are

High Strength Aluminum Castings



. . . with guaranteed properties higher than those required by Federal specification. Reason: soundness and high purity.

by John V. Houston, Jr., *American Brake Shoe Co.*



Critical area
Ten str 40,600 psi
Yld str 30,100 psi
Elong (1 in.) 11%

Critical area
Ten str 38,700 psi
Yld str 29,500 psi
Elong (1 in.) 9%

Critical area
Ten str 42,100 psi
Yld str 30,100 psi
Elong (1 in.) 12%

Noncritical area
Ten str 38,800 psi
Yld str 30,000 psi
Elong (1 in.) 5%

Properties are higher *than specification values in both critical and uncritical areas, as indicated in this photo of aileron torque tube sector (half size).*

■ Type 356 aluminum sand castings for aircraft are being supplied with minimum properties one-and-a-half to two times as high as the requirements of Federal specifications for 356-T6 alloy. Properties are determined on test coupons cut from the casting itself and are guaranteed.

The high strength and uniformity of these castings, called Ductaluminum, is leading to their use in aircraft and guided missiles for such parts as aileron control sectors, rudder control supports, fuselage fittings and fuel tank elbows.

Comparison

Federal specifications require 30,000 psi tensile strength, 20,000 psi yield strength and 3% elongation in separately cast test bars. Should test bars be cut from the casting, they need only average 22,500 psi tensile strength, 15,000 psi yield strength and 0.75% elongation. This average figure frequently includes isolated areas with mechanical properties considerably below the average. The aircraft engineer compensates for these unknown weaknesses by adding a large casting safety factor, i.e., by increasing the weight of the casting.

American Brake Shoe Co. is producing two high strength grades of type 356 that meet the chemical requirements of Federal Specification QQ-A-601a-3. One grade (designated 356-S by American Brake Shoe) has a guaranteed minimum tensile strength of 42,000 psi at designated high stress areas, a minimum yield strength of 35,000 psi, and an elongation of 3%. The other grade (356-T) has a guaranteed elongation of 6% with a slight reduction in tensile and yield strengths. Properties of these grades are compared with the specification requirements in the accompanying table.

As a result of careful foundry control (see box) it is possible to guarantee the properties in selected areas of the casting. Even the less critical areas have properties that are considerably higher than those required by the Federal specifications, as shown in the photograph on the next page.

Advantages

1. *More efficient design* — The high strength levels obtained uniformly from one casting to another make it unnecessary to accept a weight penalty when designing castings for structural aircraft parts. Because designers can use loads at least 50% higher for design, it is possible to reduce weight and thus conserve horsepower in the airplane.

2. *Lower reject rate*—Reliability of soundness is important. The cost of a rough casting is often only a fraction of the cost of the finished part because of the machining and finishing required. If a machined casting must be rejected for porosity that is not detected until machining has been finished, the over-all cost may be very high. Thus, it may be more economical to pay a premium on the rough casting than to accept a standard one. One airframe producer was able to cut the rejection rate from 35% to 5% because of improved soundness.

Applications

Major use for these new high strength grades will probably be replacements for type 195 or 220 aluminum castings, magnesium castings, or aluminum forgings.

Replace other castings — Both the 195 and 220 alloys have poor reputations for reliability from lot to lot. In addition, both are more difficult to cast than 356. Duct-aluminum 356 not only provides superior strength and elongation in the actual castings, but is also easier to handle in the foundry.

The new high strength grades provide a higher strength-weight ratio than is obtained using magnesium castings. Corrosion properties, of course, are superior, and generally the casting prices are lower.

Replace forgings—The substantially increased strength offered by this material has already resulted in replacement of forgings. More intricate shapes can be made, thinner sections can be produced, and closer dimensional tolerances can be maintained. Two facts of considerable importance to aircraft design engineers, who frequently work with prototype quantities, are that tooling costs are substantially lower and delivery of initial parts can be made much sooner.

How Sound Castings Are Made

Soundness and high purity are the major requirements in securing the consistent properties that are required to guarantee strength and ductility of castings. To achieve the desired results, it is necessary to use high quality raw materials and carefully controlled foundry practices.

Proper melting practice involves stringent control of degassing. This is checked by allowing a sample from the melt to solidify under vacuum. Unsoundness resulting from incomplete degassing is readily recognized by examining a cross section of the solidified sample for porosity and microshrinkage. This procedure was adopted because x-ray inspection is not sufficiently sensitive to detect microshrinkage lower than about 2 to 3%. The metal is cast only after satisfactory soundness is obtained in the sample.

Degassing is only part of the problem, however. Improved pouring methods minimize turbulence and reduce entrapped air. Revised mold design and improved use of risers produce dense, strong castings that are pressure tight. Careful control of heat treatment results in improved homogeneity, hardness, tensile strength and elongation.

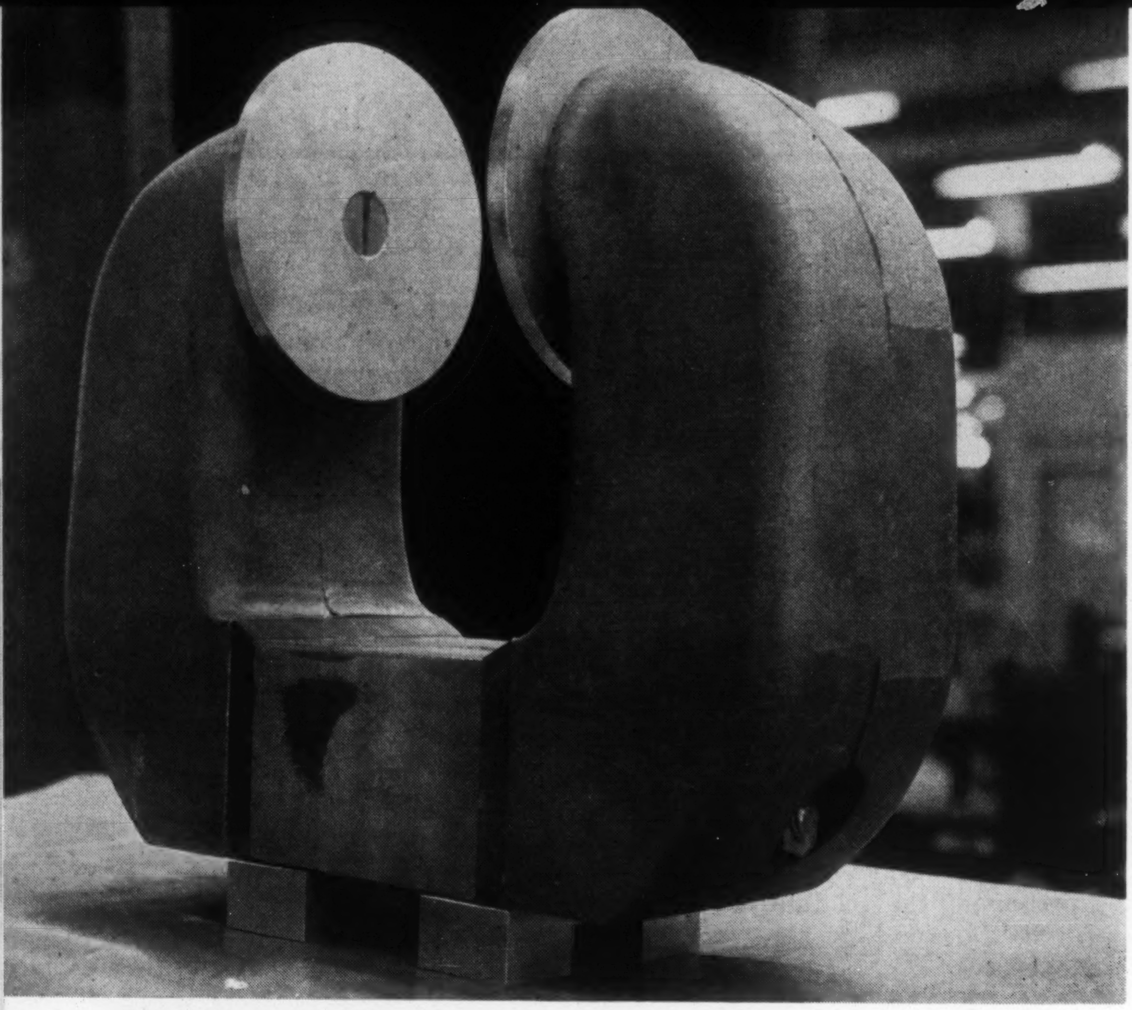
A COMPARISON OF GUARANTEED MINIMUM MECHANICAL PROPERTIES[a]

Alloy		Form	Tensile Strength, psi	Yield Strength, psi	Elongation (2 in.), %
Fed Spec QQ-A-601a-3	356-T6	Separately cast test bars	30,000	20,000	3.0
		Avg from castings	22,500	15,000	0.75
Castings Now Available	356-T[b]	Designated areas in castings	38,000	28,000	6.0
		Minimum in other areas in castings	33,000	27,000	3.0
	356-S[b]	Designated areas in castings	42,000	35,000	3.0
		Minimum in other areas in castings	36,000	32,000	2.0

[a] Federal Specification QQ-A-601a-3 requires the following analysis:

Mg	*Si*	*Cu*	*Fe*	*Mn*	*Zn*	*Ti*	*Al*
0.20–0.40	6.5–7.5	0.20 max	0.50 max	0.30 max	0.30 max	0.20 max	Bal

[b] For sections 1 in. or under, and for castings under 30 lb.



Mechanical attachment *is used to fasten pole pieces, arms and base of this 40-lb radar magnet.*

Designing with Permanent Magnet Materials

Difficulties in fabricating hard, brittle materials of the Alnico type can be alleviated by proper design. Here are some helpful suggestions on:

1. *Designing inserts*
2. *Joining*
3. *Building up surfaces*
4. *Finishing*

by R. P. Smith,
Metallurgical Products Dept.,
General Electric Co.

■ Because of their extreme hardness (Rockwell C42-58) and brittleness, permanent magnet materials of the Alnico type present a number of problems in both fabrication and assembly. In general, the only type of postforming permitted with these materials is grinding. For this reason magnets must be carefully designed at the outset to obtain as many built-in features as possible and to minimize postforming operations. Also, because of the special nature of the materials, particular care must be devoted to joining methods.

Insert design

For cast magnets—Permanent inserts can be embodied in cast magnets to provide integral drilled and tapped holes. The materials for these inserts must have a higher melting point than the surrounding metal. Also, in small magnets it is usually advisable to use a nonmagnetic insert, such as 304 stainless steel, which does not affect the magnet's magnetic characteristics. Magnet inserts composed of 303 stainless and cold rolled 1040 and 1020 steels are generally suitable for larger magnets since they do not appreciably affect magnetic properties.

For sintered magnets — Permanent inserts for sintered magnets are usually inserted into cored holes after the pressing operation and before sintering. The inserts should be knurled or burred to prevent loosening. During sintering the magnetic material shrinks around the insert and holds it fast. Consequently, it is advisable to use an insert with a coefficent of expansion less than, or at least equal to, that of Alnico. Cold rolled steel has proved quite adequate for inserts; however, magnetic considerations may dictate the use of 304 stainless.

Soldering, welding and bonding

Soldering is usually used for attaching small magnets where it is not practical to use cored holes or inserts. Despite the large iron content of Alnico magnets, soldering is made difficult by the surface formation of aluminum oxide.

Magnets can be soldered if they are properly cleaned and tinned. Dip cleaning in an electrolytic molten salt bath has proved satisfactory. Where this is not feasible, sand blasting or thorough washing can be used. Parts are usually plated after cleaning with a solderable metal such as cadmium, tin, copper or silver.

Close control during soldering is

How magnets are attached

A—Adhesives *hold pole pieces to Celastic-coated horn magnet.*

B—Rivet *fastens magnet to washing machine part.*

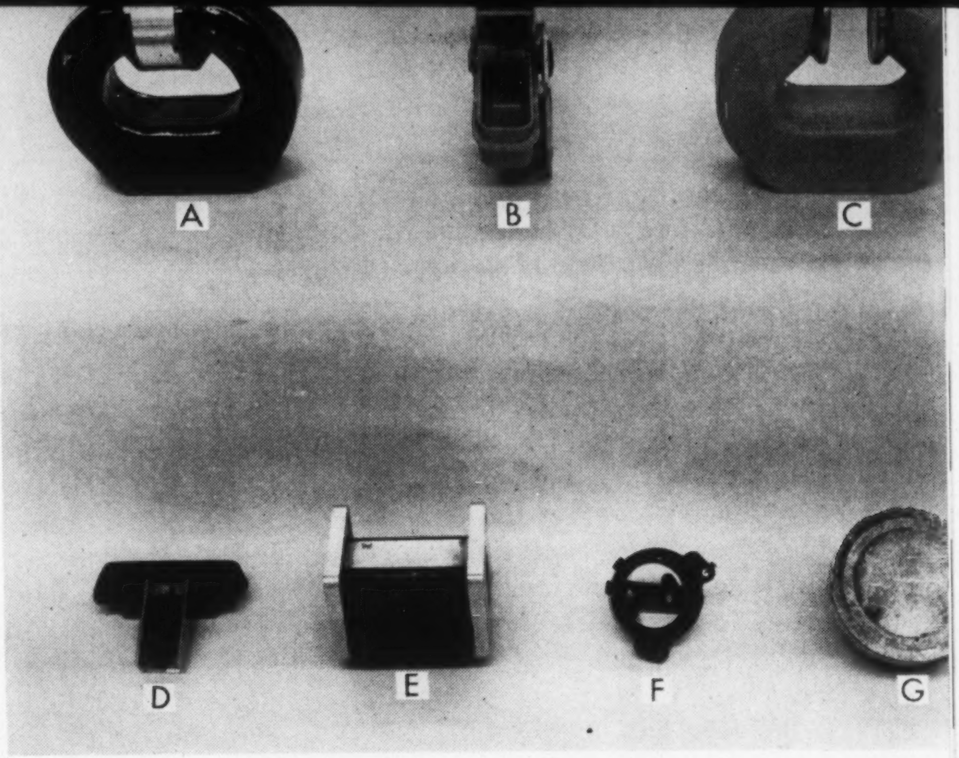
C—Casting *pole pieces in place holds units to side arms of horn magnet.*

D—Magnetic force *holds pole pieces to flashlight magnet.*

E—Soldering *is used to fasten magnet to wave guide.*

F—Injection molding *is used to fasten magnet ring for clock assembly.*

G—Bonding *with low melting alloy holds magnet inside steel casing.*



How magnets are clad

H—Die cast *cladding serves as structural support for meter magnet.*

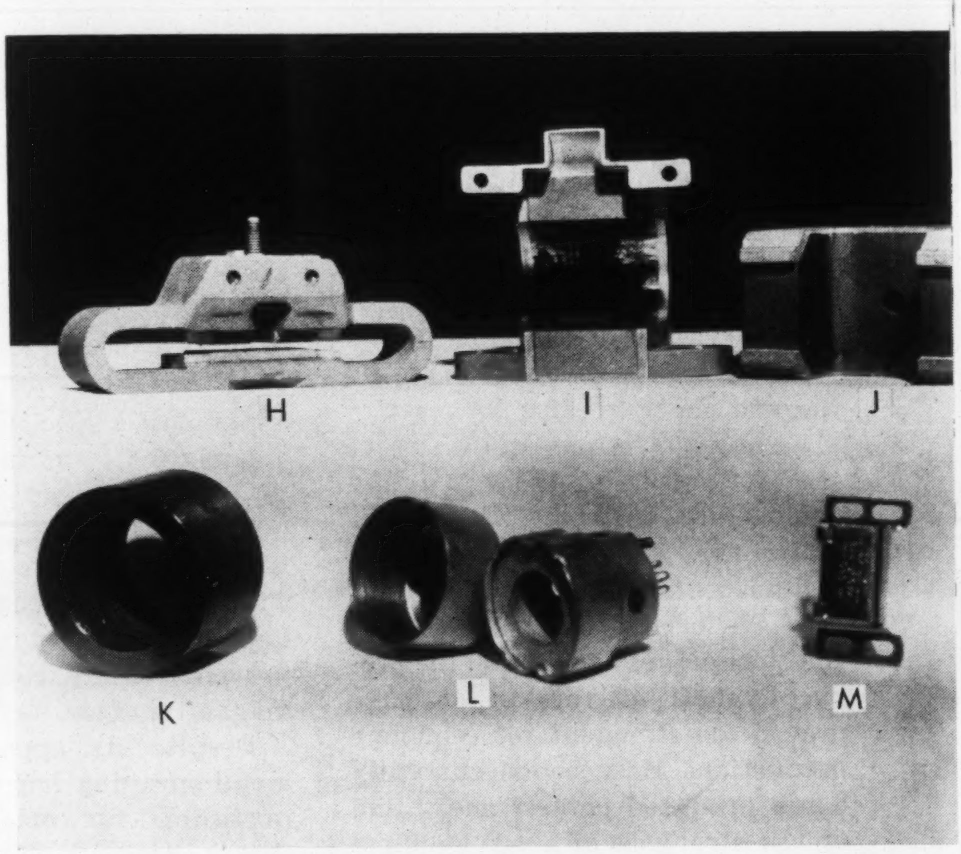
I—Die cast *cladding also functions as outer structure for this magnetron magnet.*

J—Die cast *cladding is used as protective sheath for this magnet.*

K—Brass sleeving *is used around magneto magnet.*

L—Aluminum jacket *is crimped over magnet and tube socket for radar unit.*

M—Aluminum jacket *provides structural support for door latch magnet.*



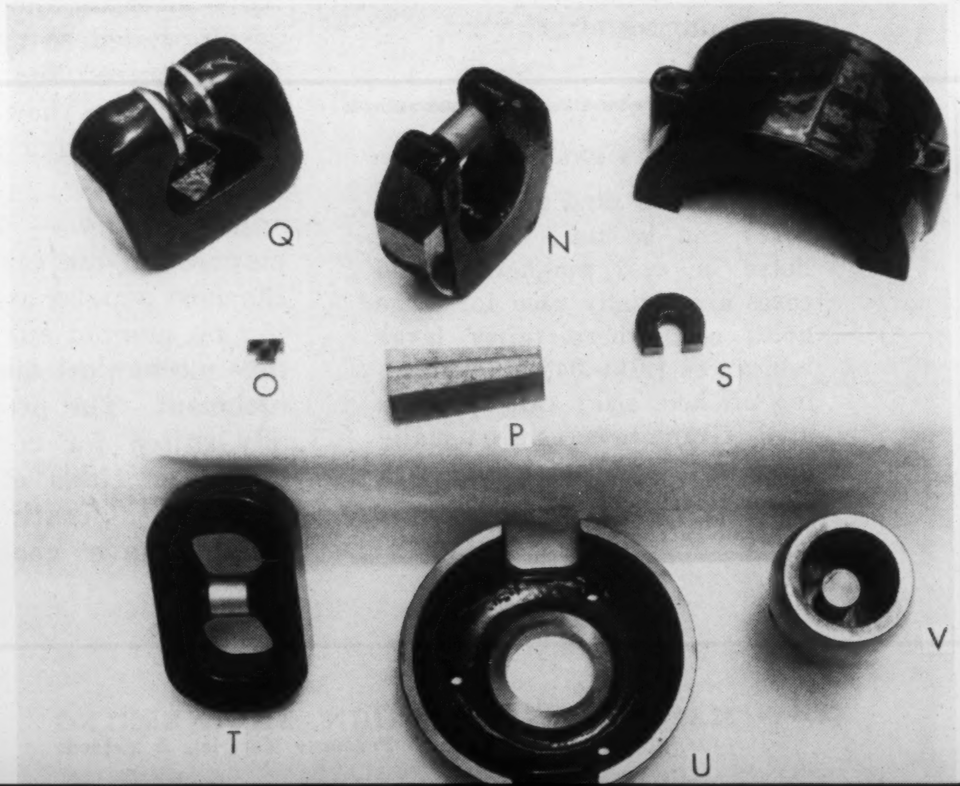
How magnets are coated

N—Celastic *coating is used on radar magnet for protection and decoration.*

O—Dye impregnant *is used on this small magnet for identification.*

P—Plating *is used to protect this magnet against corrosion.*

Q, R, S, T, U, V—Epoxy coating *is used on these magnets for decoration, insulation and corrosion protection.*



necessary since there is no alloying action between the soldering material and the basis metal. A zinc chloride flux should be applied to the magnet after it has been heated to about 390 F. Temperature should then be raised high enough to tin the magnet with a 50-50 lead-tin solder. The magnet and its mating part are then placed together until the solder flows. Since excessive temperatures can affect magnetic properties, the magnet should not be exposed to temperatures above 930 F.

Welding has proved quite satisfactory for attaching larger magnets of 1 lb and over. Good results have been obtained by arc welding with high nickel alloy and stainless steel rods. To prevent possible weld spattering, the magnet should be in a demagnetized state during welding. Extreme care must be exercised in the length of time spent at any one weld area, since Alnico materials consist of large crystals that readily break loose if the stresses set up by thermal shock become too great.

Bonding of Alnico materials to steel is most frequently accomplished with thermosetting resins. Shear strengths of up to 5000 psi and tensile strengths of up to 3000 psi have been obtained; however, the techniques required to produce values of this order have proved too stringent for economic production. Most bonds currently being produced possess shear and tensile strengths of about 2000 psi through a temperature range of -70 to 180 F. As in soldering, care should be taken to prevent overheating during attachment.

Holes in Cast Magnets

Removable sand and graphite cores can be used to produce holes in cast magnets. Sand cores are usually used for large holes and where fairly large tolerances (.014-.045 in., depending on hole size) can be tolerated. Graphite cores are usually used for smaller holes with closer tolerances.

Pole pieces are frequently attached by means of adhesive bonding. If a smooth over-all appearance and additional protection are desired, the complete assembly can then be embedded in an epoxy potting compound.

Building up surfaces

Surfaces of Alnico-type permanent magnets can be built up to: 1) facilitate mechanical and electrical attachment, 2) protect the magnet from damage and corrosion, and 3) provide a smooth surface. Surfaces can be built up by sleeves and enclosures, metal spraying or die casting.

Sleeves, enclosures — Nonmagnetic materials such as aluminum, brass, copper and stainless steel are occasionally used as sleeves to enclose a permanent magnet. They are frequently used in high speed rotors and in applications where surface porosity is objectionable. Sleeves are usually press fitted onto the magnet, and diameters are frequently machined to size. Wall thicknesses are about 0.032 in.

Metal spraying—Metal spraying can be used on permanent magnets to facilitate direct soldering and to build up surfaces so that they can be machined to close tolerances. Thickness of the coating should be kept to a minimum of 0.16 in. to prevent tools from hitting the magnet surface.

Despite its apparent benefits, metal spraying has not proved too profitable for magnet manufacturers because of the degree of surface preparation required. Grit or sand blasting has failed to remove all scale and rust and, as a result, failed to provide the surface required for good bonding. Some success, however, has been achieved by using rag wheels and hand ragging.

Die casting — Aluminum and magnesium die casting is one of the most popular methods of building up magnet surfaces to facilitate mechanical and electrical attachment. The process is especially suited for coating parts in large quantities at low cost. In addition, the coatings are light in weight, have good conductivity and mechanical strength, and are able to withstand reasonably high temperatures.

Castings are easily machined and provided with holes, and often eliminate the need for mechanical strapping when magnets must be fastened to each other. The surfaces are normally shiny and bright, and are usually sandblasted lightly to provide a satin finish which can be painted if necessary.

In general, die casting around a permanent magnet is the same as any other die casting process. Following are a few simple rules that should be observed in the design stage:

1. Keep the die simple.
2. Use uniform wall thicknesses; transitions, where required, should be smooth and tapered.
3. Strengthen thin sections with ribs.
4. Keep a minimum wall thickness of 0.06 in. around inserts.
5. Use fillets to eliminate sharp corners.
6. Eliminate undercuts to avoid die inserts.
7. Avoid uneven parting lines.
8. Allow for ejector pin marks.
9. Allow a minimum draft of ½ deg.

Finishing magnet surfaces

Alnico surfaces are frequently provided with a surface coating to prevent rusting and provide a better appearance. Surfaces can be painted or varnished; plated (chromium is frequently used); or coated with nylon, a plastic body solder or Celastic.

The Celastic coating is especially suited for protecting and decorating magnet surfaces. The coating material consists of a soft, porous, lightweight fabric sheet that is impregnated with a pyroxylin resin. When moistened with a solvent the material softens and is readily molded. After the solvent has evaporated, the material forms a hard continuous film which can be sanded smooth and painted or varnished. The material should not be molded around sharp corners or projections.

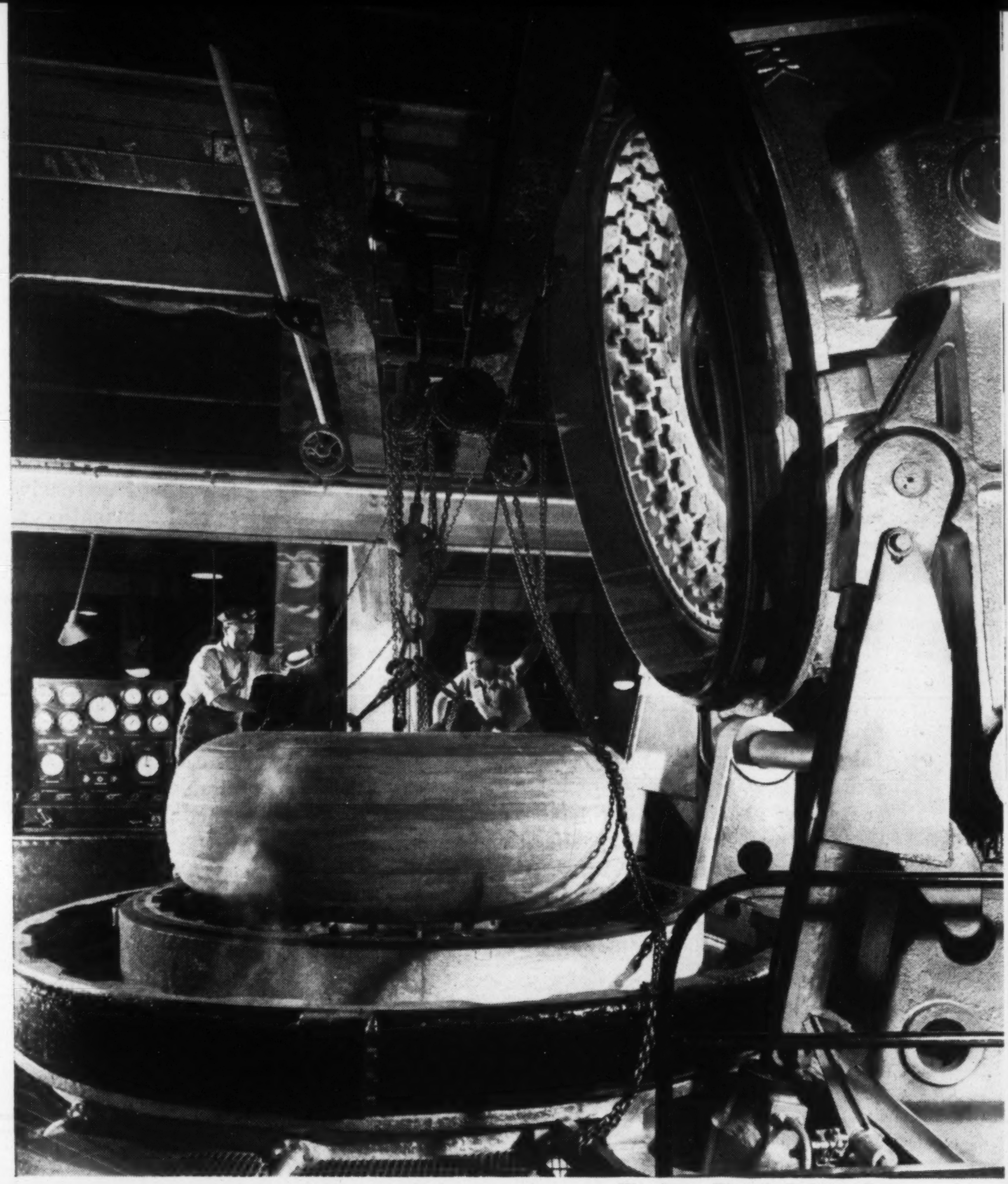
Materials
in Design Engineering

Manual No. 141—September 1957

by Malcolm W. Riley,
Associate Editor,
Materials in Design Engineering

A guide to

Synthetic Rubbers



Firestone Tire & Rubber Co.

Large tires, *though presently made of natural rubber, may be an important future use for synthetic rubber.*

Much work is being done to improve synthetic rubbers and to develop new types. The engineer who wishes to use synthetic rubbers effectively must be sure that his knowledge keeps pace with these changes. Here is a helpful, up-to-date summary of the ten basic types of synthetic rubber—their properties and their uses.

- *Styrene-butadiene*
- *Butyl*
- *Nitrile*
- *Polysulfide*
- *Neoprene*
- *Silicone*
- *Acrylic*
- *Hypalon*
- *Urethane*
- *Fluoroelastomers*

Introduction

Since World War II a great deal of research has been devoted to development of synthetic rubbers. One of the first of the large volume commercial synthetics, styrene-butadiene rubber (SBR), was developed to replace the virtually unobtainable natural rubber (NR). Most of the other synthetic rubbers have been developed to provide properties that make them suitable for use in specific service environments, e.g., oils, chemicals or high temperatures. The purpose of this manual is to summarize the various types of synthetic rubbers available, outlining the property ranges obtainable with each. (A previous article, MATERIALS & METHODS Manual No. 95, July '53, p 85, outlined considerations in designing and fabricating rubber parts, and explained how to specify them.)

Rubber should usually be bought to meet predetermined specifications and desired properties. As a general rule, the user should specify by properties as well as by type of rubber. The custom fabricator or molder can then select the type of polymer and formulate the compound to provide optimum properties at minimum cost. However, in many cases, evaluation tests are not entirely reliable, and precise property specifications cannot be established. In these cases it may be advisable for the user to specify by type of polymer. Also, the materials suppliers can provide designers and engineers with extensive data on properties and fabrication to aid in the selection of the proper type of rubber.

Each of the synthetic rubbers has properties in which it excels. Where these particular properties are mandatory in design, that type of synthetic rubber should probably be used. Thus, it is essential for the designer and engineer to keep abreast of the types available and, in general terms, what each can do for him.

Most of the tables of properties in this article list "typical" property ranges. Since each of the base polymers or gums can be compounded with a variety of ingredients, such as fillers, plasticizers, accelerators and vulcanizing agents, properties can generally be altered over a wide range. It would be impossible in this manual to include data on all the property combinations possible for each of the generic types of synthetic rubbers. Hence, the tables give representative data that indictae the range of usefulness of each material. The table on page 131 provides a general comparison of all the commercial types of synthetic rubbers. The specialty rubbers are not included.

In the following discussions, some terms may be used that are unfamiliar to the designer or engineer unaccustomed to working with rubber. Though attempts have been made to clarify these terms, the *Glossary of Terms Relating to Rubber and Rubber-Like Materials* (ASTM Special Technical Publication No. 184) published by American Society for Testing Materials, will be extremely helpful.

Styrene-Butadiene (SBR)

In general SBR rubbers have excellent resistance to aging when properly compounded. They have lower tensile strength than Hevea, less resilience or "snap," and less resistance to high temperatures. Because of their low cost and ready availability, they have been used widely.

Probably their highest volume usage is in tires, where they are used almost exclusively in passenger car tires and where they are blended with natural rubber for light truck tires. Natural rubber is still used almost exclusively for heavy truck tires.

Styrene-butadiene copolymer rubbers, commonly known as GR-S by the old designation, are the "General Purpose" synthetic rubbers developed during World War II to replace natural rubber. They are used in larger quantities than any of the other synthetic rubbers. Though the ratio of styrene to butadiene can be varied substantially, the most common gum stocks are in a ratio of about 76.5 butadiene to 23.5% styrene.

There are, at present, 45 SBR copolymers available in this country. They can be divided into six general classifications: hot types, cold types, cold oil-extended polymers, hot black masterbatches, cold black masterbatches, and cold oil-black masterbatches. Since the primary purpose of the last three types is to offer advantages to the compounder or fabricator, the designer or engineer need be concerned only with the first three types.

Classification

In general, synthetic rubbers can be classified under four groups:

1. **Non-oil resistant**
   Styrene-butadiene
   Butyl
2. **Oil resistant**
   Nitrile
   Polysulfide
   Neoprene
3. **High temperature resistant**
   Silicone
   Acrylic
4. **Specialty**
   Hypalon
   Urethane
   Fluoroelastomers

Hot types (polymerized at 122 F or higher) are primarily the original SBR rubbers and vary only in the type of stabilizer and emulsifier used.

Cold types (polymerized at 41 F) generally offer about 30% higher physical properties in compounds reinforced with carbon black, and 10 to 15% higher physicals in other compounds. They were developed more recently than hot types and, according to some suppliers, may replace corresponding hot types in the future.

Cold oil-extended types, in which a portion of low molecular weight polymer has been replaced with oil, generally have physical properties equal to or somewhat better than those of the hot types. Their primary advantage is lower cost. One of the problems with oil-extended types has been limitations on color due to the

GENERAL COMPARISON OF RUBBERS

Type ➧	Non-Oil Resistant			Oil Resistant			High Temperature Resistant	
	Natural	SBR	Butyl	Nitrile	Polysulfide	Neoprene	Silicone	Acrylic
PHYSICAL PROPERTIES								
Specific Gravity	0.93	0.94	0.91	1.00	1.35	1.25	1.2-2.6	1.09
Tensile Strength, psi								
Pure Gum	3000	400	3000	600	300	3500	200-450	400
Reinforced	4500	3000	3000	4000	1500	3500	1450	1700
Tear Resistance	Excellent	Poor-fair	Good	Fair	Fair	Good	Poor-good	Fair
Abrasion Resistance	Excellent	Good	Good	Excellent	Poor	Excellent	Poor	Good
Flex Cracking Resistance								
Slow Rate	Excellent	Good	Excellent	Good	Fair	Excellent	Fair	Good
Fast Rate	Excellent	Poor	Excellent	Poor	Poor	Excellent	Poor	Good
Compression Set Resistance	Good	Good	Good	Very good	Poor	Good	Good	Good
Resilience	Very good	Fair	Variable	Fair	Poor	Very good	Good	Poor
Elongation (max), %	700	500	700	500	400	500	300	300
Permeability to Gases	Fair	Fair	Very good	Fair-Excellent	Good	Very good	Fair	Fair
EFFECT OF ENVIRONMENTS								
Aging								
Sunlight	Poor	Poor	Excellent	Fair	Good	Excellent	Good	Excellent
Oxidation	Good	Good	Good	Fair	Good	Good	Very good	Excellent
Heat (max temp, F)	300	250	300	300	300	300	600	450
Static (in storage)	Good	Good	Very good	Very good	Very good	Very good	Good	Excellent
Water Resistance	Good	Very good	Very good	Very good	Good	Good	Fair	Poor
Alkali Resistance								
Dilute (< 10%)	Good	Good	Very good	Good	Good	Good	Fair	Poor
Concentrated	Fair	Fair	Very good	Fair	Good	Good	Poor	Poor
Solvent Resistance								
Aliphatic Hydrocarbons	Very poor	Very poor	Poor	Good-excellent	Excellent	Fair	Poor-excellent	Good
Aromatic Hydrocarbons	Very poor	Very poor	Poor	Fair-good	Good	Poor	Very poor-excellent	Good
Oxygenated Solvents	Good	Good	Good	Poor	Good	Fair	Poor	Poor
Halogenated Solvents	Very poor	Very poor	Poor	Very poor	Fair	Very poor	Very poor	Very poor
Oil Resistance								
Low Aniline	Very poor	Very poor	Very poor	Fair-excellent	Excellent	Fair	Poor	Good
High Aniline	Very poor	Very poor	Very poor	Fair-excellent	Excellent	Good	Good	Good
Gasoline Resistance								
Aromatic	Very poor	Very poor	Very poor	Fair-good	Excellent	Fair	Poor-good	Poor
Non-Aromatic	Very poor	Very poor	Very poor	Good-excellent	Excellent	Good	Good	Good
Acid Resistance								
Dilute (< 10%)	Good	Good	Very good	Good	Good	Fair	Fair	Fair
Conc (except nitric & sulfuric)	Fair	Poor	Good	Fair	Fair	Fair	Poor	Poor
Cold (min svc temp, F)	—65	—70	—65	—65	—65	—50	—180	—10

oil used. Recently developed types use oils that permit bright colored stocks.

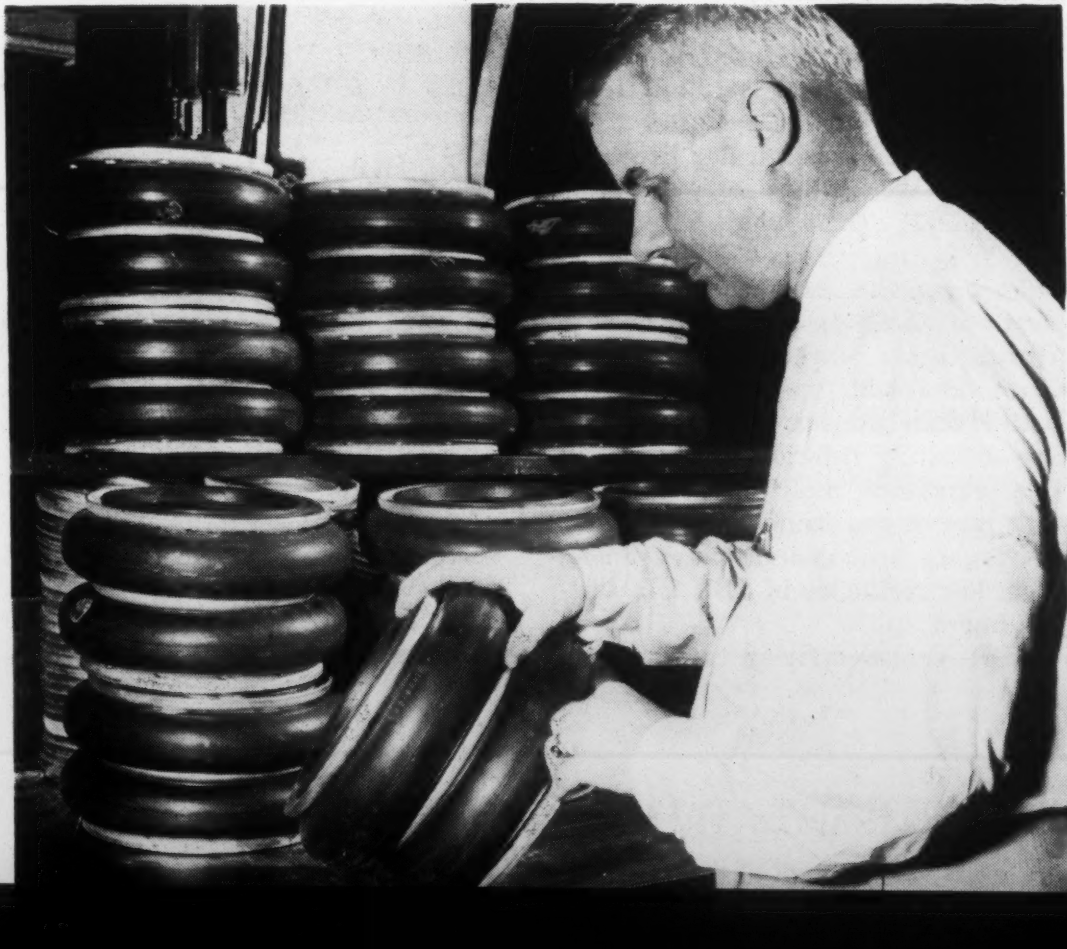
Each of these three major types can be further classified as to its content of staining, slightly staining or nonstaining stabilizers, the selection depending on end-use requirements.

Physical properties

Some rubbers crystallize on stretching, others do not. When crystallizable rubbers are stretched, the crystallites have a reinforcing effect on the rubber, improving its tensile properties. Stretching does not have a strengthening effect on rubbers which do not crystallize. SBR does not crystallize; thus, vulcanizates of the unreinforced pure gum have poor tensile strengths (on the order of 300 or 400 psi). Reinforcing SBR

Air springs, *like tires, are made with nylon cord fabric impregnated with styrene-butadiene rubber (SBR).*

Firestone Tire & Rubber Co.



stocks — with carbon black, for example — can raise tensile strength to over 3,000 psi.

Table 1 lists typical property ranges obtainable with proper compounding practice. Table 2 compares the reinforcing effects of fine particle silica, extra fine precipitated calcium silicate, and EPC (Easy Processing Channel) carbon black on a hot SBR stock. Inorganic fillers other than carbon black, such as clays, calcium carbonate, whiting, calcium silicate and zinc oxide, are used in SBR where requirements call for light color, low cost, high hardness and stiffness, or special properties such as good dielectric characteristics.

Various organic reinforcing materials are also used to provide specific properties:

1. Coumarone-indene resins increase hardness and modulus, decrease elongation and provide fairly good tensile strength. Light colored resins produce light colored stocks with only slight discoloration and staining tendency.
2. Increasing the styrene content in the copolymer results in ease of processing as well as increasing tensile strength, hardness, stiffness and flex life. Such copolymers also have low moisture absorption and good dielectric properties.
3. Special lignins provide higher tensile and tear strengths, a low modulus and generally inferior abrasion resistance.
4. Phenolic resins, which have limited compatibility with SBR gums, increase hardness and resistance to abrasion and heat, but do not increase strength significantly.

Since SBR does not crystallize when it is stretched, its flex life is better when it is flexed at low elongations than when flexed at higher elongations. In comparison, Hevea (natural), which crystallizes on stretching, has a better flex life when flexed at elongations ranging from 200 to 500% than when flexed at 0 to 300%.

Perhaps the most serious weakness of SBR as compared with Hevea is its markedly lower resilience. The cold types are somewhat better than the hot types, but both are definitely inferior to Hevea. In tire carcasses and other products that are flexed rapidly in service, the higher heat generation resulting from low resilience in SBR is a serious handicap.

SBR is also inferior to Hevea in cut growth resistance. This inferiority is more pronounced at high temperatures than at room temperature.

Properties of SBR Rubbers

TABLE 1—TYPICAL PROPERTIES

Type ➡	'Hot' Rubber	'Cold' Rubber	'Cold' Oil Extended Rubber
Tensile Strength, psi	1600–3400	3100–4200	3400–3700
Elongation, %	300–650	600–700	630–730
Modulus (300%)	800–1450	800–1200	700–1050

TABLE 2—EFFECTS OF TYPE OF FILLER[a]

Filler ➡	Fine Particle Silica	Calcium Silicate[b]	EPC Black
Tensile Strength, psi	2550	2030	3400
Modulus (300%), psi	620	890	1360
Elongation, %	620	490	560
Hardness (Shore A)	55	65	61
Tear Strength, lb/in.	200	160	300
Rebound, %	46	45	40
Heat Build-UP, F	100	80	110

[a] Measured on typical hot type SBR.
[b] Extra fine precipitated.
Source: *Whitby.*

TABLE 3—EFFECTS OF ELEVATED TEMPERATURE

Type ➡	Hevea	'Hot' SBR	'Cold' SBR
Tensile Strength, psi			
Room Temperature	4100	2900	3800
200 F	3100	1100	1500
Elongation, %			
Room Temperature	600	600	650
200 F	680	480	550
Resistance to Cut Growth[a]			
Room Temperature	1200	200	400
200 F	700	21	30

[a] De Mattia pierced groove test.
Source: *Whitby.*

Effect of temperature

SBR suffers severe losses of strength at elevated temperatures. Whereas Hevea loses approximately 25% of its tensile strength when temperature is increased from 80 F to 200 F, SBR loses about 65%. Elongation at break also decreases, and SBR's dynamic modulus is more dependent on temperature than that of Hevea. Table 3 compares the effects of temperature on typical SBR stocks and a comparable Hevea stock.

SBR has fair low temperature properties. Typical Gehman T_{10} values (temperature at which relative torsional modulus is 10 — ASTM D 1053-54T) range from –5 to –40 F, and average ASTM brittle point is about –58 F.

Resistance to fluids

As one of the non-oil resistant rubbers, usually SBR should not be used in the presence of oils, solvents or chemicals. It has poor resistance to oils, strong oxidizing agents, ozone, petroleum, solvents, and chlorinated and cyclic hydrocarbons such as carbon tetrachloride, chloroform, benzene, toluene and xylene. Table 4 compares SBR stocks and other synthetic rubbers in the way they are affected by oils and solvents.

Blends

SBR can be blended with other rubbers to obtain particular characteristics. Because of the relatively poor natural building tack in SBR itself, it is blended with natural rubber to facilitate build-up in molds for auto tires. In addition to processing advantages, natural rubber provides SBR with slightly better tensile strength, tear strength and elongation at room temperature, and much better retention of these properties at temperatures of about 200 F. Resistance to cut growth is also improved. Blending has little effect on modulus, rebound and heat build-up.

SBR can be blended with nitrile, polysulfide or neoprene rubbers to provide stocks with greater solvent resistance. Other properties of such blends are:

1) Nitrile rubbers increase tensile strength, tear resistance and elongation, but reduce rebound characteristics.

2) Polysulfide rubbers improve solvent resistance, but at a sacrifice of tensile strength, modulus, rebound and tear resistance.

3) Neoprene causes no appreciable change in tensile strength or elongation, but lowers modulus.

Blending butyl with SBR improves flex life, but lowers tensile strength, elongation, rebound and resistance to tearing.

Hard rubber, which is highly vulcanized rubber containing large proportions of combined sulfur, can be made from SBR. Chemical, physical and electrical properties of SBR hard rubbers are of the same order of magnitude as those of natural hard rubbers.

TABLE 4—EFFECT OF OILS AND SOLVENTS ON RUBBERS
(% Change in Volume)[a]

Type ➡	Styrene-Butadiene (SBR)	Nitrile (NBR)	Neoprene (CR)	Butyl (IIR)	Poly-sulfide
Kerosene	60 to 150	–5 to 20	10 to 45	100 to 800	0 to 2.5
Gasoline	75 to 200	–5 to 20	10 to 45	150 to 400	0 to 2.5
Benzene	175 to 450	75 to 250	100 to 400	100 to 200	7 to 80
Acetone	10 to 30	100 to 300	15 to 50	0 to 10	0 to 22
Ethyl Alcohol	0 to 10	–10 to 16	0 to 5	5 to 20	3
Carbon Tetrachloride	175 to 450	40 to 150	100 to 200	200 to 500	0 to 50
Lube Oil	50 to 400	–3 to 40	0 to 150	500	0 to 3

[a] All values are for volume increase except where minus sign appears.

Source: Miner, D. F., and Seastone, J. B., *Handbook of Engineering Materials*, John Wiley & Sons, Inc., 1955.

Butyl (IIR)

Butyl rubbers have outstanding impermeability to gases, excellent dielectric properties, good resistance to tearing after aging and at elevated temperatures, and relatively good chemical stability. In addition, they have excellent resistance to weather, sunlight, ozone, corona, and animal and vegetable oils. Mechanically, they have excellent resistance to tearing, flexing, abrasion, cutting and chipping.

Butyl, or IIR, previously designated GR-I, is produced by copolymerizing isobutylene with small proportions of isoprene at a temperature of about —150 F. Although butyl rubber is about 20 years old, its availability to designers and engineers has been limited. The majority of butyl has been used in tire inner tubes because of the excellent air retention characteristics of the rubber. Since 1955, when synthetic rubber plants were sold back to private industry, and with the advent of the tubeless tire, more butyl has become available for use in other applications.

In addition to tire tubes, butyl is now used for other types of inflatable goods, steam hose, conveyor belts for carrying hot materials, dairy hose, and automobile parts subject to flexing. It is also used for wire and cable insulation, and as injection molded transformer insulation. The latter application looks extremely promising with the recent development of an additive that provides the butyl with nontracking characteristics (see MATERIALS & METHODS, Nov '55, p 149).

Physical properties

Typical properties of butyl compounds are shown in Table 5.

Butyl rubber, like natural, reinforces itself by crystallizing when it is stretched. Thus maximum tensile values can be obtained by vulcanizing an essentially pure gum stock. Reinforcement does not significantly improve tensile strength, though it does increase modulus and resistance to tearing.

The self-reinforcing effect is shown in Fig 1, which compares the stress-strain curve for butyl with those for Hevea and SBR. Curves for butyl and Hevea show a sharp rise in slope due to crystallization at high exten-

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What to Call Them

Terminology in the rubber industry is, at present, somewhat unsettled. There have been recent attempts to supersede the old, and somewhat outmoded, government classifications for rubber, i.e., GR-S, GR-A, etc. The American Society for Testing Materials has published a Tentative Recommended Practice for Nomenclature for Synthetic Elastomers and Latices (ASTM D 1418-56T). For the commercial elastomers discussed in this article, the following ASTM designations are used:

SBR—Styrene-butadiene rubbers (GR-S)
IIR—Isobutylene-isoprene rubbers (butyl)
NBR—Acrylonitrile-butadiene rubbers (nitrile)
CR—Chloroprene rubbers (neoprene)
NR—Isoprene rubbers (natural)

Properties of IIR (butyl) Rubbers

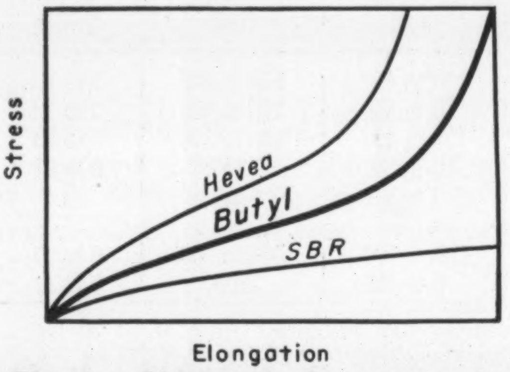


Fig 1—Stress-strain curves *for Hevea and butyl rubber show sharp upward curve due to self-reinforcing effect. Styrene-butadiene rubber shows no such upward curve because it does not crystallize when stretched.* (Whitby)

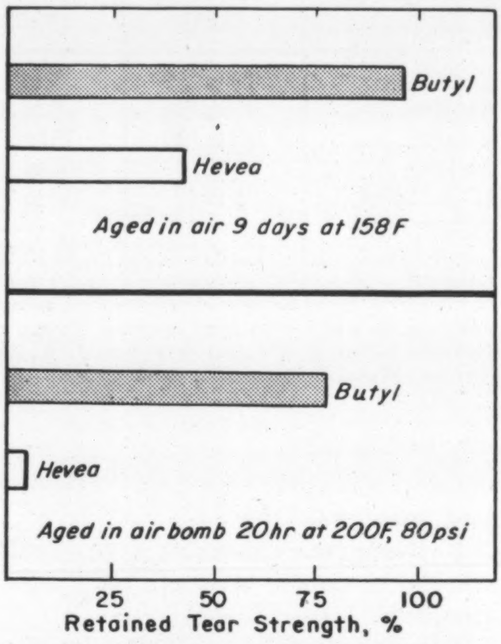


Fig 3—Heat resistance *is shown by retained tear strength.* (Whitby)

TABLE 5—TYPICAL PROPERTIES

MECHANICAL PROPERTIES[a]	
Tensile Strength, psi	2300–3000
Elongation (min), %	500–700
Modulus (400%), psi	
20-Min Cure at 307 F	400–1100
40-Min Cure at 307 F	600–1575
80-Min Cure at 307 F	850–2050
ELECTRICAL PROPERTIES[b]	
Dielectric Strength, v/mil	600
Dielectric Constant (10 v, 1000 cps)	
Dry	2.11
After 88 Hr in Distilled Water	2.10
Power Factor (10 v, 1000 cps)	
Dry	0.04
After 88 Hr in Distilled Water	0.05

[a]Stock reinforced with 50 parts (per 100 rubber) channel black. Source: Enjay Co., Inc.
[b]Pure gum stock. Source: *Whitby.*

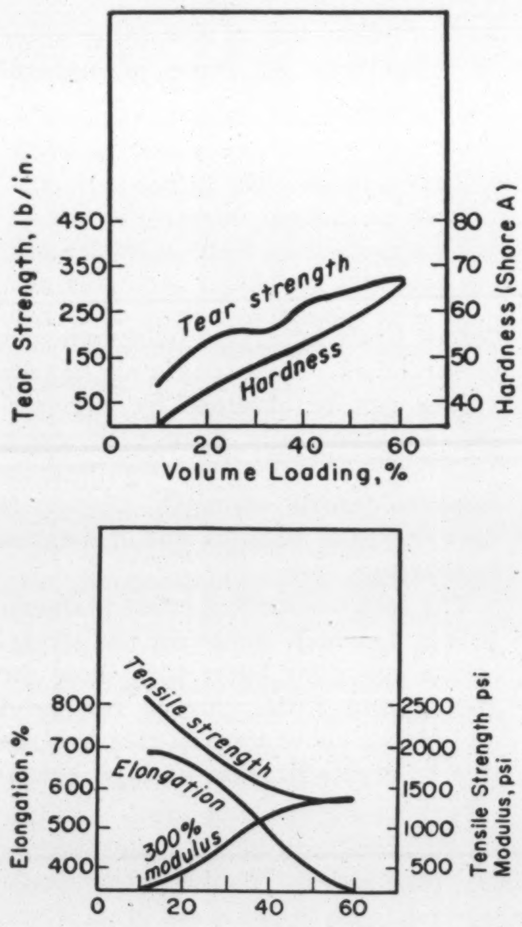


Fig 2—Effect of a typical filler *(SRF black) on properties of butyl rubber.* (Whitby)

TABLE 6—CHEMICAL RESISTANCE—BUTYL VS OTHER RUBBERS[a]

Fluid ⬇	Butyl (IIR)	Natural (NR)	Nitrile (NBR)	Fluid ⬇	Butyl (IIR)	Natural (NR)	Nitrile (NBR)
Acetone	**E**	E	P	Ferric Chloride	**E**	P	P
Acids	**E**	E	G	Furfural	**E**	E	G
Alcohols				Gasoline	**P**	P	E
Ethyl	**E**	E	E	Glycerine	**E**	E	E
Isopropyl	**E**	E	E	n-Heptane	**P**	P	E
Amyl	**E**	E	E	Hexane	**P**	P	E
Benzyl	**E**	E	E	Kerosene	**P**	P	E
Alkalis	**E**	E	G	Linseed Oil	**E**	P	E
Analine	**E**	P	P	Mineral Oil	**P**	P	E
Animal Oils, Fats	**E**	P	G	Naphtha Petroleum	**P**	P	E
Benzene	**P**	P	G	Nitrobenzene	**E**	G	P
Butyl Acetate	**E**	P	G	Iso-Octane	**P**	P	E
Butane	**P**	P	E	Ozone	**E**	P	P
Carbon Disulfide	**P**	P	G	Phenol	**E**	E	G
Carbon Tetrachloride	**P**	P	P	Phosphoric Acid	**E**	P	P
Chloroform	**P**	P	P	Propane	**P**	P	E
Cottonseed Oil	**E**	P	E	Skydrol	**E**	P	P
M-Cresol	**E**	E	E	Skydrol 500	**E**	P	P
Dibutyl Phthalate	**G**	G	P	Toluene	**P**	P	E
Diethylene Glycol	**E**	E	E	Tri-Cresyl-Phosphate	**E**	P	P
Dioctyl Phthalate	**G**	G	P	Turpentine	**P**	P	E
Ethyl Acetate	**E**	G	G	Vegetable Oils	**E**	P	G
Ethylene Glycol	**E**	E	E	Xylene	**P**	P	E

[a]Ratings are for service in fluid: E = excellent; G = fair to good; P = poor.
Source: Enjay Co., Inc.

sion. The curve for SBR shows no such rise, because it does not crystallize on stretching. Though fillers are not required for maximum tensile strength, they do affect other properties of compounds. Fig 2 shows the effect of a typical filler on tensile, elongation, modulus, hardness and tear strength of a butyl stock.

Butyl is relatively sluggish in the temperature range of —30 to 100 F. Its mechanical behavior is characterized by high internal friction and high damping power, which can be particularly advantageous for isolating and damping vibration. Proper compounding can provide a wide range of resilience without affecting the hardness of the stock.

Tear resistance of properly compounded and vulcanized butyl stocks is excellent, ranging up to 500 lb per in. and these values are retained after extended periods of aging at elevated temperatures. For example, unaged natural rubber compounds have a higher tear resistance than unaged butyl compounds. However, after two days of aging in air at 250 F, natural rubber loses nearly all of its tear strength, while butyl remains the same, or is somewhat improved. This retention of tear strength after aging is undoubtedly related to the over-all resistance of butyl to degradation in air or oxygen.

Effect of temperature

Like other elastomers, butyl is sensitive to changes in temperature. Unplasticized butyl compounds improve in resilience as temperatures increase until, at about 200 F, their resilience is comparable to that of Hevea. Resistance of butyl compounds to elevated temperatures is shown in Fig 3 which compares tear strength retention of butyl and Hevea after aging.

Butyl stocks can be compounded to have relatively good low temperature flexibility. Brittle temperatures of —60 to —70 F can be obtained by using freeze resistant plasticizers, by using coarse-particle pigments, or by vulcanizing to a high degree.

Resistance to fluids and gases

Table 6 shows the general chemical stability of butyl rubber. It has excellent resistance to most acids and bases, and to a wide variety of inorganic salts, including metal salts that are known to accelerate oxidative breakdown of Hevea even in extremely low concentrations.

In contact with organic chemicals or solvents, butyl rubber behaves in a manner typical of hydrocarbon rubbers. Butyl swells in the presence of hydrocarbon solvents, particularly paraffins. Polar liquids, such as alcohols, ketones, esters and glycols, have little or no solvent action. Some alcohols may actually cause a decrease in volume because of extraction.

Butyl is remarkably resistant to animal and vegetable oils, exhibiting only slight swelling on contact. For example, after three months' immersion at room temperature, swelling of butyl rubber in linseed and soybean oil is only 10 and 6% by volume, respectively. Hevea under the same conditions swells 124 and 106% respectively.

Halogens attack both vulcanized and unvulcanized butyl in the presence of light. The reaction produces rapid deterioration in molecular weight. If a strip of butyl stock is suspended in bromine gas, for example, in a matter of minutes the specimen becomes fluid enough to drop to the bottom of the vessel.

Reaction of butyl to various gases is variable. Hydrogen sulfide causes reversion (softening) of butyl stocks; carbon dioxide and nitrogen are definitely less harmful than air; ammonia increases modulus; and sulfur dioxide produces initial degradation, followed by an equilibrium state during which no further breakdown occurs.

Oxygen absorption rate of butyl rubber is very low. Butyl rubber has a higher absorption rate than silicone rubber, but a lower rate than polysulfide, styrene-butadiene, neoprene, high-styrene SBR, and Hevea. The effect of this absorbed oxygen on properties of butyl differs from that of other rubbers. Butyl invariably softens when heated in an oxidative atmosphere, whereas polymers such as SBR and nitrile become brittle (Hevea initially softens and then hardens gradually until brittle).

Although butyl is not completely immune to attack by ozone, normal vulcanization with sulfur produces resistance far exceeding that of natural rubber. Ozone resistance can be further improved by proper compounding.

Electrical properties

Because butyl is a nonpolar, unsaturated hydrocarbon, it possesses excellent electrical properties (see Table 3). In addition to these inherently good properties, butyl's resistance to water, ozone, weathering, bacteria and fungi make it an excellent electrical insulating material.

Enjay Co., Inc.

Automotive applications *for butyl rubber (IIR) include rubberized fabric for convertible tops, accelerator bellows, dust boots, bushings, grommets and window seals.*

Nitrile (NBR)

Nitrile rubbers have extremely good oil resistance, implying low solubility, low swelling, and good tensile strength and abrasion resistance after immersion in gases and oils. All stocks have good resistance to common solvents except acetone, benzene and carbon tetrachloride.

Nitrile rubber, or NBR (previously designated GR-A), is a copolymer of acrylonitrile and butadiene. The material, first known as Buna

B. F. Goodrich Chemical Co.

Filter leaves, *molded of nitrile rubber (NBR), are providing excellent service in a new line of industrial filtration equipment developed by Industrial Filter & Pump Co. for handling both corrosive and noncorrosive liquids.*

N, was originally developed in Germany. Properties of the rubber can be altered by altering the ratio of acrylonitrile to butadiene, and several types wiith different acrylonitrile and butadiene contents are available. In general, as acrylonitrile content increases: 1) oil resistance improves, 2) tensile strength increases, 3) processability improves, 4) resilience drops, resulting in higher compression set, 5) low temperature flexibility suffers, and 6) hysteresis characteristics deteriorate. Most commercial nitrile rubbers contain 20-40% acrylonitrile.

So-called "cold" nitrile rubbers (polymerized at 41 F) are also available. Such rubbers have improved tensile strength and increased solubility in aromatic hydrocarbons, simplifying processing.

One of the major uses for nitrile rubbers is in the form of latex (finely divided dispersion in water); in this form it is used as an adhesive, as a modifier for other water-dispersed resins, and as an impregnant for paper, textiles and leather.

Physical properties

Nitrile rubbers do not crystallize when stretched; thus reinforcements are necessary in order to provide appreciable tensile strength. These rubbers do, however, react spectacularly to reinforcement with carbon black. Table 7 lists typical properties of representative nitrile stocks compounded for specific types of service.

Stress-strain behavior of nitrile rubber is quite similar to that of natural rubber at low elongations, but at high elongations nitrile rubber shows greater plastic flow because of the noncrystallizable nature of the polymer.

Nitrile stocks have only about 33 to 60% of the resilience of natural rubber. The decrease in resilience as temperature is lowered is particularly noticeable in nitrile rubber. For example, in a 60 durometer stock, the temperature at which 25% of applied vibrational energy is absorbed is 5 F, as compared with −10 F for a comparable natural rubber stock.

The diffusion of various gases through nitrile rubber is quite different from that through hydrocarbon rubbers (see Table 8). The polar groups in nitrile rubber reduce the solubility of nonpolar gases and hence retard their rate of diffusion. Highly polar gases are more soluable in and diffuse more rapidly through nitrile than through hydrocarbon rubbers.

Effect of temperature

Nitrile rubbers deteriorate only slightly on mild heating. Resistance to elevated temperatures is dependent on compounding. Typical retention of properties after elevated temperature exposure is shown by the following data for an intermediate-acrylonitrile content NBR stock. Values given are before and after accelerated aging for 70 hr at 250 F.

	Before	After
Ult Ten Str, psi	2800	2300
Ult Elong, %	475	215
Hard. (Shore A)	63	73

Nitrile rubbers of relatively low acrylonitrile content have good low temperature flexibility. There is a linear relationship between the second order transition point (the temperature below which the rubber is glass-like) and the acrylonitrile content; the higher the content, the higher the transition point. Typical second order transition temperatures may range from −68 to 5 F.

Resistance to fluids and gases

In general, nitrile rubbers swell more in polar solvents than in nonpolar. However, swelling in water and in antifreeze solutions is low enough to permit use of nitrile rubbers in contact with these liquids. Oil resistance of stocks used in automotive cooling systems is particularly important, since oil is often deliberately added to antifreeze solutions to reduce corrosion.

Nitrile rubbers are soluble in aromatic hydrocarbons, chlorinated hydrocarbons, ketones, esters and nitro compounds. They are insoluble in aliphatic hydrocarbons, hydroxyl compounds and acids. However, there are vast differences among these solvents in rate and degree of swelling, and service tests are the only sure way of determining the utility of nitrile rubbers for specific applications involving contact with solvents.

Through proper selection of antioxidants and proper compounding, nitrile stocks that have better resistance to oxidation than natural rubber can be produced. Exposure to sunlight increases the rate of oxidation of nitrile rubber, whereas subsequent heating counteracts this effect. Additional resistance to sunlight and ozone cracking can be obtained by blending nitriles with a polyvinyl chloride resin.

Electrical properties

Nitrile rubber has a relatively low specific resistance of 3 to 50 x 10^{10} ohm per sq cm. By adding conductive fillers, fairly conductive stocks can be developed. Soft stocks containing acetylene black can have resistances as low as 100 to 500 ohm per cu cm. These stocks are useful for dissipating static charges and for electric heating units.

Blends

Nitrile stocks can be blended with various other types of rubbers to provide specific characteristics.

1. Though natural rubber is essentially incompatible with nitrile rubber, homogeneous two-phase blends can be made. Blending with natural rubber or with SBR can provide stocks that have either no shrinkage at all in hot oil, or definite prescribed swelling under specific service conditions.

2. Blending acrylonitrile-styrene copolymers with nitrile stocks produces tough, leathery materials with good tensile properties and resistance to ozone. Such materials are particularly well suited for use as exterior covers for wire or cable.

3. Polysulfide rubbers can be blended with nitrile to provide higher tensile strength than is obtainable in pure polysulfide, and better resistance to solvents than is obtainable in pure nitrile rubbers.

4. Acrylic rubber provides nitrile rubbers with higher heat resistance.

5. Polyisobutylene, though extremely limited in compatibility, provides some improvement in ozone resistance at the expense of increased dielectric loss and decreased tensile strength.

6. Minor proportions of polyvinyl chloride resin increase resistance to sunlight, ozone, fire, abrasion and tearing. Such blends are used for insulation, unsupported upholstery fabric, and as a leather substitute.

A new high strength nitrile rubber was developed recently. In addition to butadiene and acrylonitrile, it contains one or more acrylic type acids. In comparison with standard nitrile rubbers, the new stocks have higher tensile strength and modulus, lower elongation, higher hardness, improved hot tear and tensile strengths, better low temperature flexibility, and superior retention of physical properties after hot oil and hot air aging.

Properties of NBR (nitrile) Rubbers

TABLE 7—TYPICAL PROPERTIES OF STOCKS COMPOUNDED FOR VARIOUS USES

Type or Use ➜	Pure Gum	Fast Curing	Low Set	Soft	Gasoline Hose Tube	Heat Resistant	Tread
MECHANICAL PROPERTIES							
Tensile Strength, psi	600	3500	2400	500	2200	3800	4200
Elongation, %	600	600	405	450	400	650	445
Modulus (300%), psi	200	1000	1700	200	1900	1000	2600
Hardness (Shore A)	50	71	58	36	69	71	77
Tear Strength (crescent), lb/0.1 in.	7	37	18	5	35	39	30
Compression Set (40% const defl), %	9	23	7	12	7	10	9
Rebound (Schopper), %	24	13	34	54	27	13	14
Brittle Temperature, F	–66	–40	–66	–66	–58	–13	–66
CHEMICAL RESISTANCE[a]							
Hexane	4.5	0	0	–6.1	0	3.0	1.5
Benzene	210	135	105	115	86	102	127
Carbon Tetrachloride	64	37	26	12	23	37	37
Acetone	345	225	151	192	145	235	176
Ethanol (95%)	15	8	3	–10	3	8	9
Distilled Water	0	1.5	0	0.8	3	1.5	0
SAE 20–W Oil	0	0	–1.5	–6	0	0.8	0
Gasoline (X–70)	9.2	3.7	1.5	–9.2	3	4.5	4.5
Kerosene-Benzene (95–5)[b]	2.2, 0	0, 4.5	0, 0	–4.5, –17	0, 0	1.5, 6	0.8, 12

[a] Per cent volume change after 48-hr immersion at room temperature.

[b] Figure following comma is per cent volume change after 48-hr immersion at 212 F.

Source: *Whitby*.

TABLE 8—GAS PERMEABILITY—NITRILE VS OTHER ELASTOMERS

Gas ➜	Hydrogen	Oxygen	Nitrogen	Carbon Dioxide	Methane	Helium
COMPARED WITH NATURAL RUBBER						
Natural (NR)	100	100	100	100	100	100
Nitrile (NBR)	**29**	**18**	**14**	**23**	**11**	**38**
Styrene-Butadiene (SBR)	78	72	73	92	73	76
Neoprene (CR)	26	17	14	19	11	—
COMPARED WITH HYDROGEN						
Natural (NR)	100	46	17	260	56	59
Nitrile (NBR)	**100**	**28**	**7.7**	**200**	**21**	**76**
Styrene-Butadiene (SBR)	100	43	16	310	52	57
Neoprene (CR)	100	29	8.6	190	24	—

Source: *Whitby*.

Polysulfide

Polysulfide rubbers have excellent resistance to oils, solvents and water, and extremely low permeability to gases. They also have good aging characteristics, exceptional resistance to ozone, and good electrical resistivity.

Polysulfide rubbers, sold under the Thiokol trademark and first introduced in 1930, are prepared by the reaction of a sodium polysulfide with an organic dichloride. There are several types available: Type A is the simplest chemical type; it has a service temperature range of 10 to 180 F. Type FA has improved resistance to low temperatures and a less objectionable odor than Type A; it has a service temperature range of —45 to 250 F. Type ST has a still wider range of servicibility: approximately -65 to 300 F. Liquid polysulfide polymers are also available; these grades, LP-2 and LP-3 (see MATERIALS & METHODS, May '55, p 110), are used primarily for sealing, caulking and flexible patterns. Most of the discussion here is concerned with the ST type.

Polysulfide rubbers are used in gas hose for cars and service stations; oil loading hose; printers' rolls and newspaper blankers; paint spray hose; cable coverings; and miscellaneous diaphragms and gaskets. Liquid polymers are used in protective coatings, and as adhesives.

Properties of Polysulfide Rubbers

TABLE 9—TYPICAL PROPERTIES[a]

Hardness (Shore A) ➡	50	60	70	80
ORIGINAL PROPERTIES				
Tensile Strength, psi	675	950	1200	1250
Elongation, %	400	360	320	230
EFFECT OF HEAT[b]				
Tensile Strength, psi	525	810	1120	1100
Elongation, %	260	240	230	160
Hardness (Shore A)	50	60	68	80
EFFECT OF ASTM NO. 1 OIL[b]				
Tensile Strength, psi	650	875	1125	1250
Elongation, %	310	280	280	200
Hardness (Shore A)	48	57	67	75
Volume Change, %	—2	—1	—1	—1
EFFECT OF ASTM NO. 3 OIL[b]				
Tensile Strength, psi	550	760	1125	1200
Elongation, %	270	280	280	220
Hardness (Shore A)	43	50	55	65
Volume Swell, %	5	5	5	5

[a] Thiokol ST. [b] 70 hr at 212 F.

Source: Thiokol Chemical Corp.

Physical properties

Pure gum vulcanizates of polysulfide rubbers have relatively poor mechanical properties; hence compounds generally contain reinforcing pigments, such as carbon blacks. Type ST polysulfide can be compounded to provide hardnesses ranging from about 50 to 90 Shore A. Table 9 lists typical properties of ST stocks of varying hardness, compounded for specific purposes. High proportions of the tensile properties are retained after immersion in solvents. In some cases stocks may display higher tensile strengths after immersion than other solvent resistant synthetic rubber stocks which have higher initial strengths.

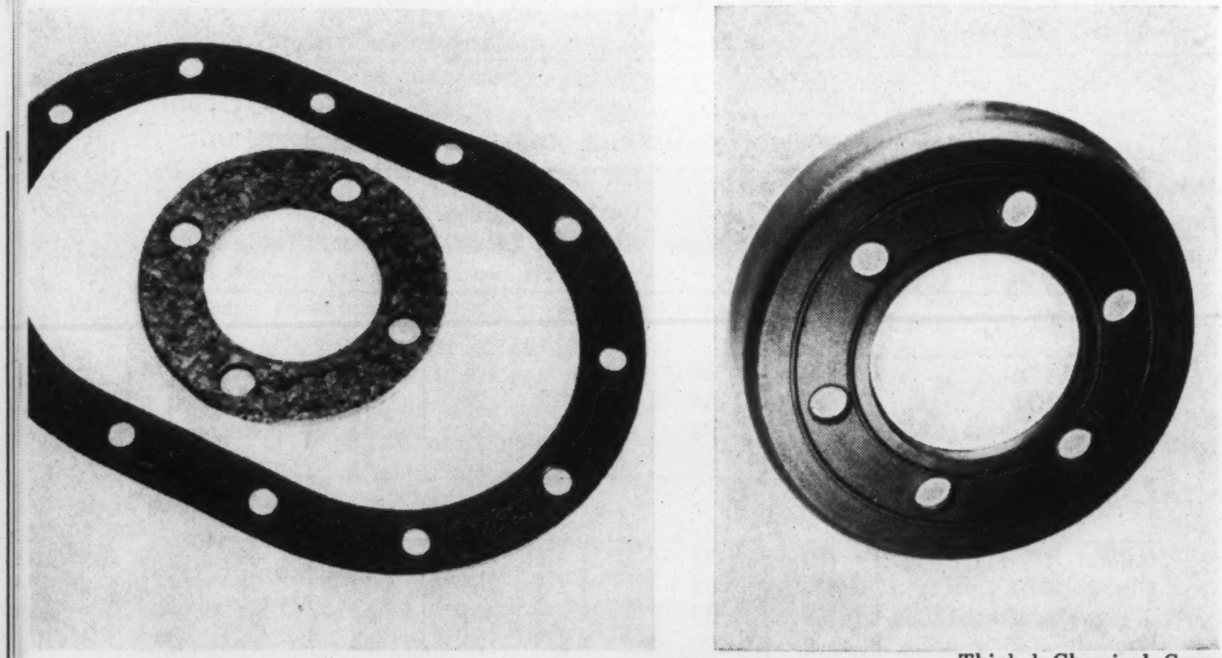
Good grade black-reinforced stocks have abrasion resistance about one-half as good as that of good grade natural rubber tire tread. Under oil exposure conditions, these same stocks have better resistance to abrasion than the natural rubber stock.

Compression set characteristics of polysulfide rubbers are only fair. Values may range from 35 to 53% for properly cured stocks. This range can be dropped to about 20 to 30% set by heat aging and conditioning.

Effect of temperature

Type ST polysulfide rubber does not soften materially at elevated temperatures. It can be used continuously at 212 F, and intermittently at temperatures up to 300 F.

Type ST polymers with no plasticizers have a torsional modulus of



Thiokol Chemical Corp.

***Packings and gaskets** of leather (right) and cork (left) may provide much better sealing characteristics and durability when impregnated with polysulfide rubber.*

TABLE 10—CHEMICAL RESISTANCE[a, b]
(30-Day Immersion at 80 F)

Solvent	Volume Increase, %	Condition of Stock
ALIPHATIC AND AROMATIC HYDROCARBONS		
Mineral Oil	-2	OK
Benzene	110	Tender
Toluene	70	Swollen but OK
Xyiene	41	OK
HALOGENATED HYDROCARBONS		
Carbon Tetrachloride	46	OK
Ethylene Dichloride	230	Very tender
Trichloroethylene	159	Tender
Perchlorethylene	28	OK
Monochlorobenzene	161	Tender
ALIPHATIC AND AROMATIC FUELS, OILS AND SOLVENTS		
SR-6	14	OK
SR-10	1	OK
ASTM Reference Fuel A	2	OK
ASTM Reference Fuel B	10	OK
100 Octane Gasoline	2	OK
ASTM Oil No. 1	-4	OK
ASTM Oil No. 3	-2	OK
Turpentine	4	OK
Diesel Oil	3	OK
Circosol 2XH	-2	OK
Drip Oil	62	Sl tender
Pydraul F-9	37	OK
Skydrol	24	OK
Sovaloid N	2	OK
Sundex 53	-1	OK
Tetrahydrofuran	175	Very tender
JP-4	1	OK
ORGANIC ACIDS		
50% Acetic Acid	26	OK
Glacial Acetic Acid	18	OK
Cresylic Acid	123	Tender
ESTERS		
Ethyl Acetate	35	OK
Butyl Acetate	30	OK
Dibutyl Phthalate	10	OK
Plasticizer SC	6	OK
Dibutyl Sebacate	2	OK
Dioctyl Phthalate	-2	OK
Tricresyl Phosphate	7	OK
Adipol BCA	20	OK
VEGETABLE AND WOOD OILS		
Linseed Oil	-2	OK
Cottonseed Oil	-2	OK
Castor Oil	-3	OK
Corn Oil	-4	OK
White Pine Oil	14	OK
Crude Soya Bean Oil	-4	OK
HYDROXY COMPOUNDS		
Ethyl Alcohol (denatured)	2	OK
Butyl Alcohol	2	OK
Isopropyl Alcohol	0	OK
Diacetone Alcohol	18	OK
Prestone	3	OK
Methyl Alcohol	6	OK
Ethylene Glycol	0	OK
Glycerine	1	OK
KETONES AND ETHERS		
Acetone	37	OK
Methyl Ethyl Ketone	35	OK
Methyl Isobutyl Ketone	24	OK
Ethyl "Cellosolve"	14	OK
Dibenzyl Ether	30	Very tender
Butyl "Cartitol"	13	OK
INORGANIC COMPOUNDS		
Sulfuric Acid (10%)	2	OK
Sulfuric Acid (20%)	-2	Sl soft
Sulfuric Acid (50%)	—	Deter. 2 wks
Nitric Acid (10%)	—	Deter. 2 wks
Hydrochloric Acid (10%)	3	OK
Hydrochloric Acid (50%)	3	Tender
Hydrochloric Acid (100%)	—	Deter. 1 day
Sodium Hydroxide (20%)	2	OK
Sodium Chloride (10%)	3	OK
Copper Sulfate (10%)	5	OK
Zinc Chloride (10%)	2	OK
Water	5	OK

[a] Thiokol ST. [b] ASTM D 471-54T, Method B.
Source: Thiokol Chemical Corp.

$G_{10,000}$ at —60 F (ASTM D 1043-51). This temperature can be lowered by use of suitable plasticizers.

Resistance to fluids and gases

Type ST stocks have good resistance to a wide range of solvents (see Table 10). Shrinkage is negligible in low swell solvents. The elastomer is practically unaffected by gasoline, kerosene, fuel oil and lubricating oils. Aromatic-blended fuels, such as ASTM Reference Fuel B, swell the rubber about 10%.

Alcohols, glycols, water, aqueous solutions of neutral salts, and dilute acids have little effect. Dilute nonoxidizing acids cause slight softening, whereas concentrated acids and oxidizing types cause deterioration.

As can be seen in Table 10, volume increases up to 30% have little effect on strength and other characteristics of ST stocks. Increases of 30 to 70% can be tolerated in many cases. Beyond 70% swell, simulated service tests should be conducted to determine the suitability of the material for specific applications.

Resistance of ST stocks to sunlight and ozone is excellent. After one and a half year aging in air, stocks show a slight increase in hardness and a decrease in elongation. Tensile strength remains constant, and there is no tendency to soften or become brittle. Practically no change in physical properties is detectable after 70 hr at 158 F and 300 lb oxygen pressure in an oxygen bomb.

Type ST has low permeability to gasoline, aromatic blends, and other volatile liquids and solvents (see Table 11).

Blends

Polysulfide rubbers can be blended with nitrile or neoprene rubbers to obtain a balance of properties unobtainable with either polymer alone. The higher ratios of nitrile or neoprene provide improved stress-strain properties, and higher tear strength and resistance to compression set both before and after heat aging. However, these properties are obtained at some sacrifice in resistance to aromatics, aromatic blended fuels, ketones and esters. Low temperature flexibility also suffers.

TABLE 11—PERMEABILITY
(Oz/in./24 hr/sq ft)

Solvent	75 F	175 F
Benzene	0.54	1.75
Diisobutylene	Negligible	Negligible
SR-6	0.02	0.08
Methyl Ethyl Ketone	0.28	0.65
Ethyl Acetate	0.14	0.55
Methyl Alcohol	0.005	0.13
Carbon Tetrachloride	0.042	0.24

Source: Thiokol Chemical Corp.

Neoprene (CR)

Neoprene stocks have good resistance to oils, oxidation, aging, sunlight, ozone and chemicals. They also have a high degree of resistance to abrasion, cutting and chipping, and will not support combustion. Properly compounded neoprene stocks are serviceable over a temperature range of –60 to 250 F. Some compounds can be used in intermittent exposure at temperatures up to 450 F.

Neoprene is a synthetic rubber-like polymer made by polymerizing chloroprene, or by copolymerizing chloroprene with other monomers. It was introduced in 1931. Several types of neoprene are available, some for general purpose use and some for very special applications. Since the bulk of neoprene rubbers used is of the general purpose type the discussion here is centered around this type. Table 12 lists typical applications for neoprene, classified by the most important property determining the use.

Physical properties

Neoprene crystallizes when stretched; thus it can have high tensile strength in pure gum form. Although gum tensile strengths as high as 5200 psi have been recorded, average strength of neoprene gum stocks ranges between 2500 and 4000 psi. Properties of several typical compounds are shown in Table 13.

Such properties of neoprene as heat build-up and resilience are generally superior to those of other synthetic rubbers, and only slightly inferior to those of natural rubber. Fig 4 shows the relationships between hardness vs resilience, and hardness vs heat build-up for neoprene as compared with natural rubber.

Though compounding with fillers raises tensile strength of gum stocks, reinforcing materials have an even more striking effect in raising resistance to tear and abrasion. For example, the addition of 30 parts per hundred of channel black results in tear strength values several times those of the gum vulcanizate.

Neoprene stocks can be compounded to have low compression set characteristics, particularly at elevated temperatures. For example, one stock, conditioned at 30% deflection for 70 hr, has compression set characteristics of 13% at 158 F, 18% at 212 F, and 20% at 250 F. Corresponding set of natural rubber is 20% at 158 F, 28% at 212 F, and 38% at 250 F.

Properties of CR (neoprene) Rubbers

TABLE 12—PROPERTIES AND APPLICATIONS

Significant Property	Rating	Typical Applications
Oil Resistance	Good	Curb pump hose, work shoe soles, v-belts, hose for handling petroleum products.
Abrasion Resistance	Very good	Heavy duty conveyor belts, hose covers, footwear
Ozone and Weather Resistance	Exceptional	Electric cable jackets, air hose, gaskets, marine parts
Low Temperature Flexibility	Fair	Radome coatings, automotive and aircraft parts
Heat Resistance	Good	Brake diaphragms, ignition wire covering, lamp gaskets, protective clothing
Flame Resistance	Good	Mine trailing cables, conveyor belts
Compression Set Resistance	Good	Motor mounts, gaskets, rolls

Source: E. I. du Pont de Nemours & Co., Inc.

TABLE 13—TYPICAL PROPERTIES

BLACK WIRE JACKET STOCK	
Original	
Tensile Strength, psi	2300
Elongation, %	340
Stress at 200%, psi	1575
Resistivity, ohm-cm	9.6×10^7
Dielectric Strength, v/mil	113
ASTM No. 2 Oil (18 hr, 250 F)	
Tensile Strength, % retained	100
Elongation, % retained	77
Water Absorption (7 days, 158 F), mg/sq in.	54
190 F APPLIANCE WIRE INSULATION STOCK	
Original	
Tensile Strength, psi	2000
Elongation, %	500
Modulus (200%), psi	700
Hardness (Shore A)	67
Air (10 days, 250 F)	
Tensile Strength, % retained	91
Elongation, % retained	60
Hardness (Shore A)	82
Air (60 days, 212 F)	
Tensile Strength, % retained	80
Elongation, % retained	65
Hardness (Shore A)	80
EXTREME COLD-RESISTANT TUBING	
Tensile Strength, psi	1500
Elongation, %	670
Hardness (Shore A)	48
Stress at 300%, psi	700
Solenoid Brittle Point, F	–76
RESILIENT MOUNTING STOCK	
Tensile Strength, psi	3500
Elongation, %	620
Stress at 400%, psi	1600
Hardness (Shore A)	48
Resilience (Yerzley)	81
Static Modulus (Yerzley, 20% def), psi	775
Dynamic Modulus (Yerzley, 20% def), psi	950
Heat Build-Up (Goodrich flexometer, 20 min, 3/16-in. stroke), F	77
Compression Set (Method B, 70 hr, 212 F), %	23

Source: *Whitby.*

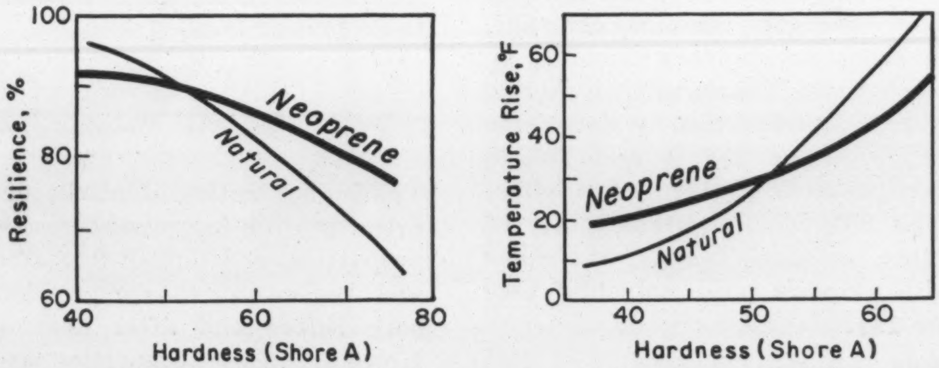


Fig 4—Effect of hardness *on resilience and temperature rise for neoprene as compared with natural rubber.* (Malcolmson)

Effect of temperature

Neoprene has relatively good heat resistance. Unlike natural rubber, which fails by becoming soft and sticky, neoprene gradually becomes harder on exposure to heat and eventually fails through embrittlement. In general, neoprene can be used continuously at temperatures up to about 250 F. In intermittent service, compounds have been used at temperatures of 350 to 450 F.

Neoprene has relatively good low temperature flexibility. Brittle points often range around —40 to —50 F. Where stocks are compounded particularly for low temperature applications, brittle points may be as low as —65 or even —95 F.

Resistance to fluids and gases

In contact with oils and solvents, neoprene has excellent resistance to: 1) straight-chain hydrocarbons, even when substantial amounts of aromatic constituents are added as in some types of aviation gasoline; 2) aliphatic hydroxy compounds, such as methyl and ethyl alcohols and ethylene glycol; 3) animal and vegetable fats and oils; and 4) most Freon refrigerants.

Neoprene is unsuitable or has limited serviceability when used in contact with: 1) chlorinated hydrocarbons, such as chloroform and benzylchloride; 2) organic esters, such as butyl acetate and methyl salicylate; 3) aromatic hydrocarbons, such as toluene and benzene; 4) aromatic hydroxy compounds, such as phenol and cresol; and 5) some ketones, especially mixed ketones such as methyl ethyl ketone.

In contact with other chemicals, neoprene has excellent resistance, even at elevated temperatures, to: 1) dilute mineral acids, except strong oxidizing acids; 2) alkalis, including concentrated sodium and potassium hydroxides; and 3) solutions of inorganic salts, except those of a strong oxidizing salt.

Neoprene is unsuitable for or provides limited service in contact with strong oxidizing agents such as nitric acid, concentrated sulfuric acid and hydrogen peroxide.

Neoprene has excellent resistance to oxygen and ozone. Unlike natural rubber, which tends to become soft and sticky when oxidized, neoprene after prolonged periods of aging in oxygen merely hardens at a slow rate.

For example, in one oxygen test it took approximately 40 days' exposure in an oxygen bomb at 158 F and 300 psi pressure to reduce tensile strength of a lightly loaded neoprene stock to 50% of original value. Corresponding time for natural rubber was only about 20 days. Similarly, in an ozone test, neoprene was not detectably affected during an exposure of 3 hr to an ozone concentration sufficient to rupture natural rubber after 3 min. Because of this combination of oxygen and ozone resistance, as well as its excellent resistance to sunlight, neoprene is extremely resistant to weathering.

Electrical properties

The dielectric properties of neoprene are somewhat inferior to those of natural rubber and SBR stocks; however, they are sufficient for low voltage insulation. Volume resistivities of about 10^{10} ohm-cm can be obtained. Dielectric strength of typical commercial compounds ranges from 150 to 550 v per mil. Conductive compositions having resistivities as low as 100^{2} ohm-cm can also be made.

Flame resistance

Neoprene is one of the few synthetic rubbers that will not support combustion. Organic in nature, neoprene is consumed by fire but will burn only in the presence of a supporting flame because of its high chlorine content. This property can be of critical importance in specifying neoprene where propagation of flame would be unduly hazardous.

Silicone

Silicone rubbers are one of the most stable groups of rubbers known. They are highly resistant to high and low temperatures, ozone, oils and chemicals. There are six major types to choose from: 1) general purpose, 2) extreme low temperature, 3) extreme high temperature, 4) low compression set, 5) high tensile-high tear, and 6) fluid resistant.

Chemically, silicone rubbers are polysiloxanes of various types. The four basic types of polysiloxane gums that are commercially available are dimethyl, methylphenyl, methylvinyl and methylphenylvinyl. Recently a methyl trifluoropropyl polysiloxane gum was developed to provide a high degree of resistance to fluids and chemicals. Silicone rubber was covered extensively in two recent articles (MATERIALS & METHODS, May '57, p 140, and June '57, p 114).

Physical properties

Typical properties of some silicone rubber stocks are shown in Table 14. Tensile properties of most silicone rubbers are relatively poor, ranging from about 600 to 850 psi. The high tensile-high tear stock, developed fairly recently, provides tensile strengths on the order of 1100 to 1700 psi, elongations of 500 to 700% and tear strengths of 175 to 250 lb per in.

Fillers provide improvements in mechanical strengths. However, the majority of the silicone rubbers, with the exception of the vinyl-containing gum, cannot be reinforced with carbon black, but must use silica.

Standard compression set values obtainable with most silicone rubbers range around 30 to 50% (22 hr at 350 F); however, low compression

TABLE 14—PROPERTIES OF SOME TYPICAL SILICONE RUBBERS

Type ➡	General Purpose				High Tensile-High Tear	Reversion Resistant	Fuel Resistant
Hardness (Shore A)	25 ±5	40 ±5	50 ±5	70 ±5	50 ±5	60 ±5	60 ±5
Tensile Strength, psi	700	700	750	600	1450	800	850
Elongation, %	450	300	300	75	750	175	225
Tear Strength, lb/in.	30	60	75	100	200	100	75
Compression Set (22 hr, 350 F), % orig deflection	30	36	40-50	20-25	50[a]	20[b]	30[c]
Max Service Temp, F							
Intermittent	450	500	480	500	400	500	350
Continuous	600	600	600	600	450	700	450
Low Temp Flexibility (min temp), F	—100	—85	—65	—65	—100	—85	—85

[a] 22 hr at 300 F. [b] 20 hr at 350 F. [c] 70 hr at 212 F.

set stocks provide typical values of 12 to 20%.

Effect of temperature

General purpose silicone rubbers withstand service temperatures over a range of —65 to 500 F. Extreme low temperature stocks have brittle points approaching —180 F and are quite flexible at —120 to —130 F. Physical properties of low temperature compounds are about the same as those of general purpose stocks, with some reduction in oil resistance. Extreme high temperature stocks are serviceable at temperatures up to 600 F, and withstand brief exposures at 700 F.

Resistance to fluids and gases

In general, the resistance of silicone rubbers to certain solvents and oils has been relatively poor. The fluorine-containing type has been developed primarily to overcome this shortcoming. Resistance to four common solvents is shown below. The data represent per cent volume increase of fluorosilicone rubber after seven days' immersion at 75 F.

Iso-octane	15
Xylene	19
Ethyl Alcohol	5
Acetone	181

More complete data on resistance of fluorosilicone rubber to chemicals, fuels and hot fluids are given in MATERIALS IN DESIGN ENGINEERING, July '57, p 94.

Connecticut Hard Rubber Co.

***Heat resistant parts** of silicone rubber shown here include extrusions (upper left), moldings (center) and assemblies.*

Electrical properties

Electrical properties of silicone rubber compounds are comparable to those of the best organic rubbers in the ordinary temperature range. Moreover, silicone rubbers maintain these electrical properties over a temperature range of —100 to 500 F or higher. Also, exceptional resistance to ozone, corona and weathering make the materials well suited for electrical insulation. Dielectric strength ranges approximately from 350 to 500 v per mil, volume resistivity from 10^{15} to 10^{11} ohm-cm, dielectric constant from 2.7 to 5.0, and power factor from 0.0005 to 0.1.

Acrylic

Acrylic rubbers are primarily noted for resistance to high temperatures (300 to 400 F), and resistance to swelling and deterioration in oils (particularly sulfur-bearing oils) at elevated temperatures. They can be made to have excellent flex life. They are highly resistant to oxidation at normal and elevated temperatures, and to sunlight and ozone. They have low permeability to hydrogen, helium and carbon dioxide. Resistance to water, alcohol, acetic acid and other oxygenated solvents is very poor. Most acrylic rubbers are not recommended for applications below –10 F.

Acrylic, or polyacrylate, rubbers are based on polymers of butyl or ethyl acrylate and were first developed in 1944. The elastomer is usually made by copolymerizing ethyl acrylate with chloroethylvinyl ether.

A major increase in the use of acrylic rubbers has occurred in applications such as car transmission seals, which require high operating temperatures because of the trend toward smaller, lighter weight and more efficient transmissions. Acrylic rubbers are also used in oil hose, gaskets and o-rings, where sulfur-containing oils and high pressure lubricants are encountered. Other uses: belting, tank linings, white or pastel colored goods, cements, and latex coatings for glass fiber cloth.

TABLE 15—TYPICAL PROPERTIES OF ACRYLIC RUBBER

Property	Typical Value	GMS Spec Value[a]
ORIGINAL		
Tensile Strength, psi....	1880	1000 min
Elongation, %..........	270	150 min
Hardness (Shore A).....	66	70 ± 5
Compression Set (Method B), %[b].....	30	40 max
EFFECTS OF AGING[b]		
Air		
Tensile Strength, %.....	0	—10 max
Elongation, %........	—15	—20 max
Hardness, pts........	+2	0 to +7
ASTM #1 Oil		
Tensile Strength, %...	+2	—10 max
Elongation, %........	+11	—25 max
Hardness, pts........	+4	—5 to +5
180-Deg Bend........	OK	OK
ASTM #3 Oil		
Tensile Strength, %...	—6	—10 max
Elongation, %........	+15	—25 max
Hardness, pts........	—10	—10 to 0
Volume Change, %...	+16	0 to +20
180-Deg Bend........	OK	OK

[a] General Motors Corp. specification.
[b] 70 hr at 300 F.
Source: *Gillette.*

Physical properties

Typical mechanical property ranges obtainable are: tensile strengths of 500 to 2200 psi, elongations of 100 to 400%, and hardnesses of 40 to 100 Shore A. Compression set (Method B) may range from 30 to 40 or higher, depending on the compound. Table 15 shows properties, both original and after aging, of a typical acrylic rubber.

Resilience of acrylic rubbers is relatively low and heat build-up relatively high, limiting applications to some extent.

Acrylic rubbers have excellent resistance to aging at temperatures of 300 F and higher. Though they are not recommended for use where flexibility below −10 F is required, properly compounded stocks can pass the low temperature flex test at −30 F.

Effect of fluids and gases

Resistance of acrylic rubbers to hydrocarbon oils at temperatures of 300 F and above is excellent. A typical compound, after immersion in ASTM No. 1 oil at 300 F for 70 hr and 200 hr, showed a volume change of −2 and −1%, respectively. After 70 and 200 hr at 300 F in ASTM No. 3 oil, the same compound showed a volume increase of 8 and 9%, respectively. The rubber is particularly resistant to effects of high pressure type lubricants at high temperatures.

Acrylic rubbers are not recommended for use in water, steam or water soluble liquids such as methanol or ethylene glycol. They decompose in alkaline media and are swelled by acid solutions.

Acrylic rubber has unsurpassed resistance to discoloration in sunlight. Exposure in an Atlas Fade-O-Meter for 100 hr has little or no effect on these stocks, whereas such exposure discolors conventional rubbers.

Electrical properties

Acrylic rubbers have fair dielectric properties, which improve on exposure to elevated temperatures. This characteristic, coupled with excellent ozone resistance, makes the rubber suitable for special purpose wire insulation. In comparison with vinyl insulation, acrylic rubbers after aging several days at 300 F have superior dielectric strength. After aging four weeks, the acrylic loses only 5 to 6% of original weight and shows no indication of shrinkage or brittleness; the plasticized vinyl loses 42% of its weight, shrinks considerably and becomes very brittle.

Hypalon (chlorosulfonated polyethylene)

Hypalon has extremely good resistance to oxidation, whether caused by sunlight and weather, chemicals, high temperatures or ozone concentrations. The elastomer also has good mechanical properties and unlimited colorability.

Introduced in 1952 and trademarked Hypalon, the elastomer is a chlorosulfonated polyethylene in which there is about 29% chlorine and 1.25% sulfur. The material can be used as a stock in itself, or it can be used to blend with other types of elastomers. It also provides many benefits as a coating material (see MATERIALS & METHODS, Jan '57, p 96).

Physical properties

Tensile strength of Hypalon ranges from 500 to 2800 psi, depending on the formulation. Hardness ranges from 55 to 95 Shore A. Table 16 lists typical properties obtainable. Although resilience of Hypalon is generally lower than that of natural rubber and most synthetics at room temperature, it is equal to or better than that of other elastomers at 212 F. The relatively high compression set can be lowered by proper formulation, and flex life and abrasion resistance are very good. The material will not support combustion when properly cured.

Effect of temperature

Most formulations can be used continuously at temperatures up to 250 F, and for intermittent service at 350 F.

Hypalon will not become brittle at temperatures of −65 to −80 F, though it will stiffen at temperatures below 0 F unless specifically compounded for low temperature resistance.

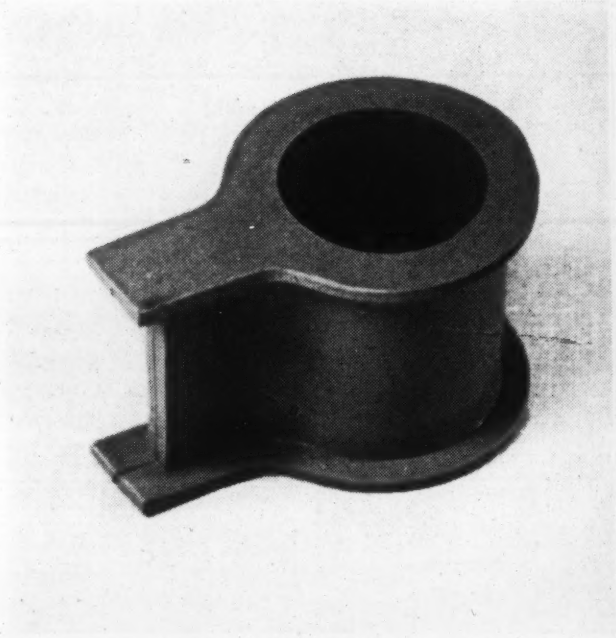
Resistance to fluids and gases

Hypalon is unaffected by ozone. Specimens stretched to 25% elongation have been exposed to ozone concentrations up to 10,000 ppm at temperatures up to 160 F for 72 hr with no ill effect. Also, specimens exposed in both laboratory and outdoor weathering tests for 30 months show negligible effects on both properties and appearance.

Hypalon also has good resistance to chemicals, particularly strong oxidizing chemicals (see Table 17). The material also has relatively good resistance to oils and grease. It is not recommended for use in continuous contact with either aromatic or chlorinated hydrocarbons.

Electrical properties

Hypalon has a dielectric strength ranging from 400 to 750 v per mil, resistivity of 1×10^{14} ohm-cm, dielectric constant at 1000 cps of 5 to 7, and a power factor at 1000 cps of 2 to 3%.



Acushnet Process Co.

Pump liner *made of Hypalon is used in a Vanton pump to handle fuming nitric acid.*

Blends

Hypalon can be blended with various other rubbers to provide a range of properties.

1. In blends with natural rubber, Hypalon improves resistance to ozone and weathering.

2. Hypalon can be used to improve further the inherently good ozone resistance of butyl rubber, as well as its modulus, and resistance to heat and abrasion.

Properties of Hypalon Rubber

TABLE 16—TYPICAL PROPERTIES

Tensile Strength, psi	500–3500	Brittle Temperature, F	–40 to –80
Elongation, %	250–450	Ozone Resistance	Complete
Modulus at 100%, psi	300–3000	Oil Resistance	Fair to good
Hardness (Shore A)	45–95	Heat Resistance	Very good
Compression Set (Method B), %	20–60	Chemical Resistance	Very good in oxidizing chemicals
Resilience (Yerzley, rm temp), %	55–70		
Resilience (Yerzley, 212 F), %	85–90	Weather Resistance	Excellent
Abrasion & Flex Resistance	Outstanding	Color Retention	Very good

Source: E. I. du Pont de Nemours & Co., Inc.

TABLE 17—CHEMICAL RESISTANCE[a]

Little or no effect

- Ammonia (liq anhyd)
- Chlorine Dioxide (14%, 150 F)
- Chromium Plating Soln (158 F)
- Chromic Acid (50%, 200 F)
- Chromic Acid (conc)
- Cottonseed Oil
- Diethyl Sebacate
- Dimethyl Ether
- Ethylene Glycol (158 F)
- Ferric Chloride (15%, 200 F)
- Ferric Chloride (sat.)
- Formaldehyde (37%)
- Freon-12
- Hydrochloric Acid (37%, 122 F)
- Hydrochloric Acid (48%, 158 F)
- Hydrogen Peroxide (50%, 212 F)
- Hydrogen Peroxide (88.5%)
- Methyl Alcohol
- Mineral Oil
- Motor Oil (SAE 10)
- Nitric Acid (to 20%, 158 F)
- Nitric Acid (70%)
- Phosphoric Acid (85%, 200 F)
- Pickling Solution (20 HNO_3-4% HF, 158 F)
- Potassium Hydroxide (conc)
- Sodium Dichromate (20%)
- Sodium Hydroxide (20%, 200 F)
- Sodium Hydroxide (50%, 158 F)
- Sodium Hypochlorite (20%, 200 F)
- Stannous Chloride (15%, 200 F)
- Sulfur Dioxide (liq)
- Sulfuric Acid (to 50%, 200 F)
- Sulfuric Acid (to 80%, 158 F)
- Sulfuric Acid (to 95.5%)
- Tetrabutyl Titanate
- Tributyl Phosphate
- Water (200 F)

Moderate effect

- Acetic Acid (glacial)
- Acetone
- Aniline
- Chlorine (liq)
- Cottonseed Oil (158 F)
- Diethyl Ether
- Hydrochloric Acid (37%, 158 F)
- Mineral Oil (212 F)
- Motor Oil (SAE 10, 158 F)
- Nitric Acid (70%, 122 F)
- Sulfuric Acid (95.5%, 122 F)
- Turbo Oil No. 15

Severe effect

- Acetic Acid (glacial, 158 F)
- Carbon Tetrachloride
- Citrus Oils
- Dichlorobutane
- Formaldehyde (37%, 158 F)
- Gasoline
- Hydrochloric Acid (37%)
- Jet Engine Fuel (JP-4)
- Nitric Acid (30%, 158 F)
- Nitric Acid (fuming)
- Nitrobenzene
- Perchlorethylene
- Turbo Oil No. 15 (350 F)
- Xylene

[a] Room temperature except where noted.

3. In nitrile rubber, Hypalon provides a combination of oil and ozone resistance, as well as good low temperature properties, without the use of plasticizers.

4. In SBR stocks, Hypalon improves ozone resistance.

5. The relatively good ozone resistance of neoprene can be further improved by blending with Hypalon. Such blends also have better heat resistance than neoprene alone, and lower compression set than Hypalon alone. Brittleness temperature is lowered to some extent, hardness and modulus are increased, elongation is decreased, and compression set is increased sharply. Oil resistance of such blends is not quite as good as that of neoprene alone.

Properties of Urethane Rubbers

TABLE 18—TYPICAL PROPERTIES

Type ➡	Vulkollan[a] 18	Vulkollan 30
MECHANICAL PROPERTIES		
Ten str, psi	5500-7000	4500-5500
Elongation, %	600-800	450-500
Modulus, psi		
100%	475-550	1200-1400
300%	1200-1500	2700-3000
Elong Set, %	3-10	35-45
Tear Str, lb/in.	450-525	550-700
Hard. (Shore A)	78-83	93-96
Elasticity, %	50-60	45-50
ELECTRICAL PROPERTIES		
Breakdown Voltage, v/mil[b]	450	525
Sur. Resist. (24 hr in H_2O), ohm	5×10^{10}	1×10^{11}
Vol Resist., ohm	2×10^{11}	3×10^{11}
Vol Resist. (4 days, 80% RH)	5.6×10^{9}	2×10^{10}
Vol Resist. ohm-cm	5×10^{10}	3×10^{11}
Dielec Const		
800 Cycles	7.6	6.7
10^6 Cycles	7.1	6.4
Loss Factor		
800 Cycles	0.016	0.017
10^6 Cycles	0.058	0.050
THERMAL PROPERTIES		
Ther Cond Btu/hr/sq ft/°F/in.	1.6	1.6
Coef of Ther Exp, per °F	111×10^{-6}	96×10^{-6}

[a] Registered trademark of Farbenfabriken Bayer.
[b] Sample 80 mil thick.
Source: Mobay Chemical Co.

TABLE 19—SOLVENT RESISTANCE (% Swelling at Room Temperature[a])

Type ➡	Vulkollan 18	Vulkollan 30
Linseed Oil	1	0.5
Water	1.5	1.5
Mineral Oil	1.5	0.5
Mineral Spirits	2	2
Ether	10	8
Alcohol	15	8
Carbon Disulfide	15	12
Xylene	20	17
Toluene	37	25
Carbon Tetrachloride	44	33
Benzene	60	36
Ethyl Acetate	70	50
Nitro Benzene	165	85
Methylene Chloride	310	165
Acids, Alkalis	b	b

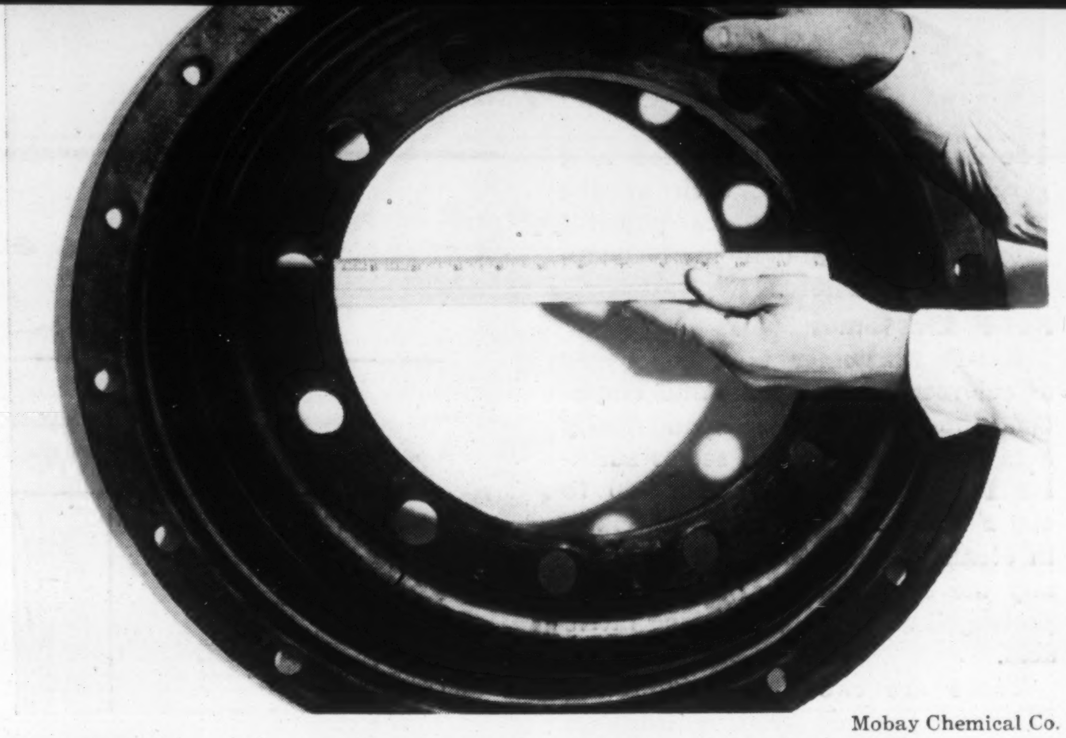
[a] Immersed until constant volume was reached.
[b] Destroyed.
Source: Mobay Chemical Co.

Urethane

Urethane rubbers are characterized by extremely good tensile strength, tear strength, hardness and abrasion resistance.

Several elastomers can be produced by the condensation reaction between polyesters and diisocyanates. Germany and Great Britain were among the first countries to do substantial development work. The British type, called Vulcaprene, has found application primarily as coatings and impregnants. The bulk of commercial work in this country has centered around the German type, trademarked Vulkollan. Most of the discussion here will concern this type.

The high degree of hardness of urethane rubbers, coupled with their good elasticity, has indicated their potential in applications such as shock absorption pads for heavy machinery, bumpers on earth moving equipment, shock absorber rings for cars, and typewriter damping pads. The excellent abrasion resistance, tear strength and moderately high coefficient of friction would seem to make urethanes applicable for such things as solid industrial tires, friction wheels and drives and drive belts.



Mobay Chemical Co.

Coupling *for ship propeller is cast in one piece of urethane rubber.*

Physical properties

Urethane rubbers are characterized by what may be the highest gum tensile and tear strengths and resistance to abrasion of any of the synthetic rubbers. Tensile strength and elongation range from 4000 to 7000 psi and 450 to 800%, respectively, depending on the type. Table 18 lists typical properties of two commercial types. Tensile modulus values are lower for the softer materials than for the harder types, and elongation set (residual elongation after release of tensile stress) increases as hardness increases.

Tear strength increases from about 280-320 lb per in. for the softer grades to a high of 550-700 lb per in. for the hardest grades. Abrasion resistance also increases in this order. Though test values differ greatly with the test method, in actual use the 78-83 durometer stock is generally said to give three to ten times the wear of natural or other synthetic rubbers. Rebound elasticity of all types is good, ranging from 45 to 60%.

Effect of temperature

Urethane elastomers can be used in dry air continuously at 175 F, for some days at 212-230 F, for several hours at 265 F, and for some minutes at 300 F. One stock has been used for 100 hr in oil at 266 F with no sign of deterioration. Continuous use in contact with hot water or steam is not recommended. The higher the hardness of the stock, the better the retention of properties at elevated temperatures.

As temperatures are lowered, urethane elastomers stiffen gradually until at about −4 to −22 F stiffening becomes much more pronounced. The materials become brittle at about −90 F. If the elastomer is stretched and maintained in the elongated state at low temperatures, it may show a 100% elongation set, but the material will recover its original dimensions upon being heated to 122 F.

Resistance to fluids and gases

In general, solvent resistance of urethane elastomers is quite good (see Table 19). Very little swelling is produced by contact with aliphatic solvents, alcohol, ether and water. Aromatic hydrocarbons cause moderate swelling, and certain solvents, such as nitrobenzene and methylene chloride, cause severe swelling. The rubber can be dissolved in dimethylformamide containing a trace of dibutylamine.

Resistance to dilute acids and alkalis for short periods of time is good, but prolonged exposure results in destruction of the elastomer. Similarly, hot water and steam eventually weaken or destroy the material.

The resistance of urethane elastomers to ozone and oxygen is excellent, since the elastomer is prepared from materials containing no olefinic unsaturation. Some discoloration may occur due to oxidation, but there is no accompanying sign of changes in crosslinking or molecular weight, and properties are not affected.

Electrical properties

Typical electrical properties of urethane elastomers are shown in Table 18. Dielectric characteristics are slightly better in the harder types. Dielectric constant ranges from 6.7 to 7.6 at 800 cps, and loss factor ranges from 0.016 to 0.017. Volume and surface resistivity are in the range of 10^{10} to 10^{11} ohm-cm; surface resistivity is reduced to 10^{6}-10^{10} after 24-hr immersion in water.

Fluoroelastomers

The important characteristics of fluoroelastomers are their resistance to chemicals and other deteriorating fluids and to extremes of temperatures. Mechanical properties, in general, are comparable to those of other synthetic rubbers.

Fluorine-containing elastomers are the newest family of rubbers. There are at present five general types (including the fluoro-silicone rubber discussed under silicone rubbers) in different stages of availability. The bulk of currently available property data was published in Materials in Design Engineering, July '57, p 90.

The discussion here is limited to a general summary of each of the types. Table 20 lists typical physical properties of the four fluoroelastomers discussed here.

Properties of Fluoroelastomers

TABLE 20—TYPICAL PROPERTIES

Type ➡	Kel-F		Fluoro-Rubber		Viton A	Fluoro-Polyester
	5500	3700	1F4	2F4		
Tensile Strength, psi						
77 F	2000	2700	1250	950	2375	2000-2200
212 F	—	1000	600	—	—	—
250 F	—	—	470	—	—	—
300 F	—	—	—	—	450	—
400 F	—	—	—	—	220	1400-1600[c]
Elongation, %						
77 F	450	325	300	300	350	110-150
212 F	—	—	180	—	—	—
250 F	—	—	155	—	—	—
300 F	—	—	—	—	225	—
400 F	—	—	—	—	60	130-175[c]
Stress at 100%, psi	500	1000	—	—	—	—
Modulus (100%), psi	—	—	280	—	300	—
Hardness (Shore A)	55	58	55	65	66	75-80
Tear Strength, lb/in.	120	150	—	—	—	—
Resilience (Bayshore), %	—	—	6	—	43	—
Compression Set (Method B)	45[a]	23[a]	28[b]	55[b]	—	—
Gehman Stiffness (T_{10}), F	23	0	12	—	-7	—
Brittle Point, F	—	—	9	-37	—	—
Volume Resistivity, ohm-cm	1.13×10^{14}	1.21×10^{14}	—	—	10^{13}	—
Power Factor, %	—	—	—	—	3-4	—
Dielectric Strength, v/mil	613	642	—	—	250-750	—

[a] 70 hr at 158 F. [b] 70 hr at 250 F. [c] Aged 168 hr at 400 F in air.

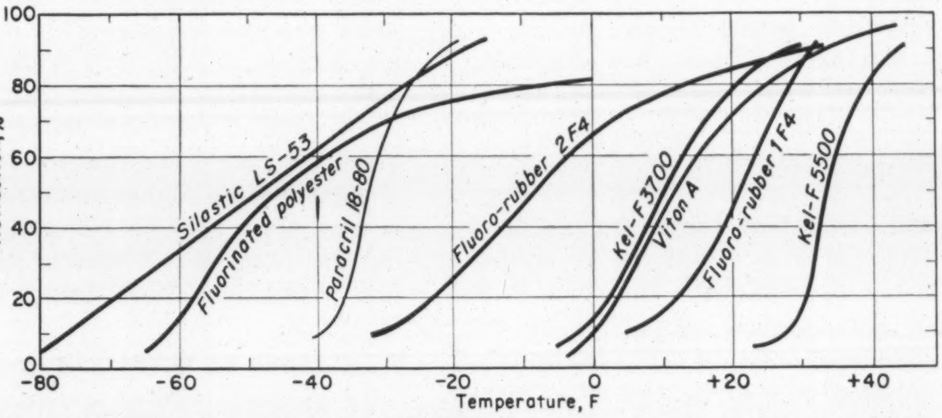


Fig 5—Low temperature behavior—*Low temperature retraction curves (ASTM D 1329-54T) compare low temperature characteristics of the fluoroelastomers, including the fluoro-silicone. A comparative curve is given for unplasticized Paracril 18-80 (a nitrile) presently being specified by the Air Force for low temperature uses in fuel and hydraulic systems.* (Griffin)

Kel-F Elastomer

Kel-F Elastomer is a copolymer of chlorotrifluoroethylene and vinylidene fluoride and is commercially available. The material seems suitable for applications in the -60 to 400 F temperature range, especially in contact with fuels. It is practically the only elastomer suitable for prolonged use with red fuming nitric acid.

There are two grades of Kel-F Elastomer: grade 3700, which is a general purpose grade; and grade 5500, which is particularly recommended for exposure to strong oxidants, such as red and white fuming nitric acids.

The elastomers have tensile strengths of 1600 to 3500 psi, elongations of 300 to 600%, and tear strengths of 150 to 400 lb per in. Modulus, hardness and tear strength can be improved by use of fillers such as silica or carbon black.

Properly compounded stocks retain physical properties after prolonged aging at 400 F. However, properties of heat aged materials, when measured at aging temperature, are substantially lower than original values.

Low temperature characteristics, as shown by the low temperature retraction curves in Fig 5, are relatively poor compared with those for other fluoroelastomers and Paracril 18-80 (nitrile rubber used for low temperature aircraft fuel and hydraulic systems).

Kel-F Elastomers resist attack by strong oxidizing acids, mineral acids, peroxides, alkalis, alcohols, aliphatic solvents, some chlorinated solvents, hydraulic fluids, silicone oils and sulfur-bearing, extreme pressure lubricants. Immersed in red fuming nitric acid, the elastomer reaches an equilibrium volume swell of 20 to 30% in one week; extensibility and hardness remain virtually unchanged, though tensile strength decreases. General chemical resistance of Kel-F elastomer is shown in Table 21.

Fluoro-Rubber 1F4 and 2F4

These elastomers are perfluorobutyl acrylate rubbers. Type 1F4 is a specification material and retains useful properties from 9 to 450 F when exposed to diester type engine lubricants. Type 2F4, available only in limited quantities, is similar in properties to 1F4 except that it has a low temperature limit of -35 F, rather than 9 F.

Mechanical properties of the elastomers are shown in Table 20. The elastomers are intended for continuous service at temperatures up to 400 and 450 F, and intermittent use at higher temperatures. Low temperature retraction curves are shown in Fig 5.

These elastomers have good resistance to a variety of fluids, including jet fuels and other petroleum products, silicate esters, and many solvents. Of particular value is their

TABLE 21—CHEMICAL RESISTANCE OF KEL-F ELASTOMER[a]

Fluid ↓	Time (days), Temp (F)	Vol Swell, %
ACIDS		
Fuming Sulfuric	27, 77	1
Hydrochloric	27, 77	16
Hydrofluoric (wet)	32, 65	15, 12[c]
Phosphoric (85%)	27, 77	1
Red Fuming Nitric	27, 77	24
SOLVENTS		
Aniline	27, 77	5, 13[c]
Carbon Tetrachloride	27, 77	33, 16[c]
Cyclohexanone	1, 77	700
Ethyl Alcohol	27, 77	6
Ethylene Dibromide	15, 77	5
Ethylene Glycol	27, 77	1
Furfuryl Alcohol	27, 77	4
Petroleum Ether	27, 77	13
Toluene	27, 77	55
Trichloroethylene	27, 77	53
Turpentine	27, 77	1
FUELS, LUBRICANTS		
ASTM Oil No. 1	27, 77	0
ASTM Oil No. 2	27, 77	1
ASTM Oil No. 3	27, 77	1
Esso Turbo Oil 15	27, 77	600[b]
70/30 Iso-Octane/ Toluene	27, 77	30, 16[b]
JP-3	27, 77	5
MLO 8200	20, 300	8, 2[b]
OS-45 (hydraulic)	14, 300	25
Silicone DC-200	7, 300	1[b]
Skydrol W-46	14, 300	70
Sour Crude	7, 300	10[b]
Swan Finch GM-4655M	3, 300	10[b]
Test Oil WA-389	3, 300	5[b]
Texamatic 1505	27, 77	1
UCON 50 HB-100	14, 300	19
OTHER REAGENTS		
Bleach Solution	27, 77	0.5
Chlorine Gas (1 atm)	7, 77	2
Freon 113	1, 77	180

[a] ASTM D-471, Method B.

[b] Results were obtained on grade 3700; all others on 5500.

[c] Results were obtained with polyamine cure; all others with peroxide.

TABLE 22—FLUID RESISTANCE OF FLUORO-RUBBER

Fluid ↓	Time, hr	Temp, F	Change in Properties			
			Ten Str, %	Elong, %	Hardness, pts	Vol, %
ACIDS						
Hydrochloric (10%)	70	212	-1	-41	+15	+11
Nitric (10%)	70	212	-57	+24	-8	+35
Sulfuric (10%)	70	212	0	-65	+26	0
White Fuming Nitric (90%)	3	77	-60	-12	-30	+74
	250	77	-77	+26	-50	+35
	1000	77	-75	+310	-54	+27
HYDRAULIC FLUIDS, OILS						
Calif. Research Oil 52742	100	212	-14	-34	+10	0
	—	300	-46	-46	+15	+3
Cellulube 300	100	350	- 7, - 5[a]	-58, 0[a]	+15, -5[a]	—
	—	400	-17, -31[a]	-62, -24[a]	+20, 0[a]	—
Cities Service A	100	300	-22	-55	+20	0
	—	350	-59	-86	+25	-2
	775	350	[b]	[b]	+48	-9
Delco No. 11	168	158	-40	-45	- 5	+10
MIL-L-7808	500	350	+19, +20[a]	-66, -17[a]	+25, +13[a]	0, +6[a]
MIL-O-5606	500	350	+11, -51[a]	-72, -57[a]	+27, +18[a]	0, 6[a]
	—	400	—	—	+43, +36[a]	-3
MLO-8200	100	350	-32	-37	+13	—
	24	500	-82	0	+10	—
Pyranol Transformer Oil	1000	212	-20	-45	- 5	+ 5
	100	300	-30	-40	+ 5	+ 3
	½	455	-10	-30	- 5	—
Shell No. 5	70	250	- 5	-45	+ 5	0
Skydrol 500	100	212	-35	-45	-15	+25
Socony-Vacuum WA-389	70	300	-10	-50	+15	0
Swan-Finch GM-4655-M	70	300	-10	-65	+15	-5
Versilube F-50	100	350	-46	-53	+26	—
	—	400	-73	-80	+30	—
	24	500	-77	-93	+38	—

[a] Tempered vulcanizate. [b] Too brittle to measure.

TABLE 23—FLUID RESISTANCE OF FLUORO-POLYESTER RUBBER[a]

Fluid →	Jet Fuel	70/30 Iso-Octane/ Toluene	Diester Oil (Plexol 201)	Hydro-chloric Acid (10%)	Sodium Chloride (10%)
Tensile Strength, psi	2950	2217	1888	2700	1756
Elongation at Break, %	325	475	425	500	500
Set at Break, %	1-2	1-2	1-2	1-2	1-2
Modulus at 300% Elongation, psi	2565	750	—	750	574
Hardness (Shore A)	69-72	57-62	54-58	57-62	54-59

[a] 168-hr immersion at room temperature; 0.025-in. dumbbell specimens of variously compounded vulcanizates.

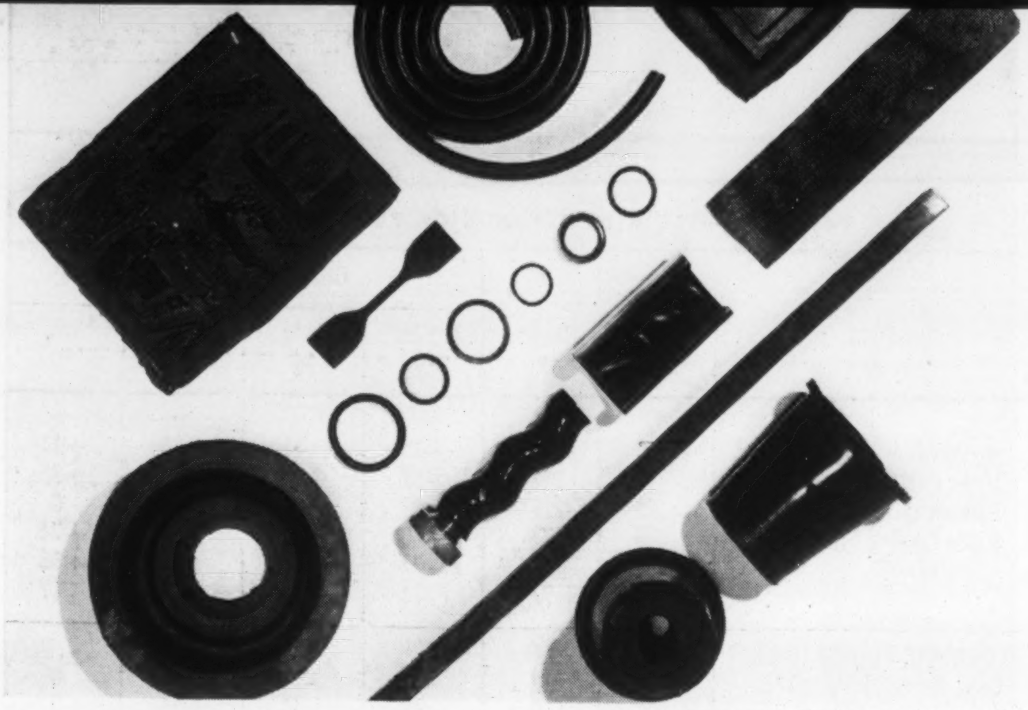
resistance to synthetic diester lubricants. Effects of various acids, hydraulic fluids and oils are shown in Table 22.

The elastomers are essentially immune to ozone attack. Strips bent in a 180-deg arc or extended 25% show no signs of cracking or other damage after one week exposure to circulating air containing 350 ppm of ozone at room temperature.

Viton A

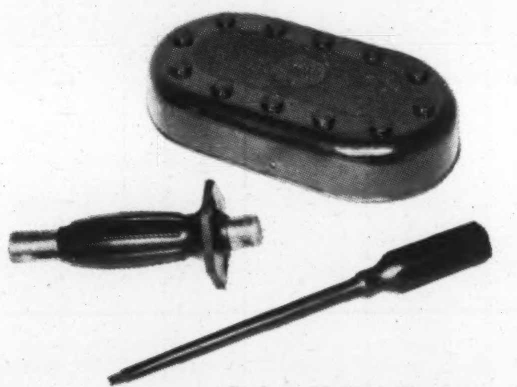
This elastomer is a copolymer of vinylidene fluoride and perfluoropropylene, and is available in limited experimental quantities. It has outstanding high temperature fluid resistance, with a possible -65 to 600 F service temperature range.

Mechanical properties are shown in Table 20. Tensile strength and elongation drop progressively as temperature increases, but there is little further reduction in properties



Minnesota Mining and Mfg. Co.

***Variety of parts** that can be molded in the fluoroelastomers is indicated by these shapes formed in Fluoro-Rubber 1F4.*



Stokes Molded Products,
Div. Electric Storage Battery Co.

***Hard rubber** is made from natural or synthetic rubber and sulfur. Other ingredients can be added to provide specific properties. Shown here (top to bottom) are an impact rubber golf bag bottom, a shock absorbent handle, and a nonconductive hard rubber-covered screwdriver.*

at temperatures above 400 F.

The material has good resistance to compression set and deformation at high temperatures. Typical compression set values (Method A, 400 psi) are 15 to 23%. By Method B, vulcanizates show 25% set at 250 F and 45% set at 350 F. The low temperature retraction curve for Viton A is shown in Fig 5.

In general, Viton A is more resistant to more fluids than any known elastomer. It is resistant to aromatic and aliphatic hydrocarbons, aromatic amines, chlorinated hydrocarbons, dilute and concentrated mineral acids and alkalis, petroleum hydrocarbons and water. In general, highly polar materials cause the most swelling. Swelling in the nonflammable hydraulic fluids is excessive. Some high swelling and low swelling fluids are listed below:

Low Swell Fluids (<25%)

ASTM No. 3 Oil—350 F
ASTM Reference Fuel B—75 F
JP-4—400 F
Nitric Acid (90%)—77 F
Oronite 8515—400 F
OS-45-1 Oil—400 F
Turbo Oil No. 15—400 F

High Swell Fluids (>100%)

Ethyl Acetate—75 F
Glacial Acetic Acid—75 F
Propyl Nitrate—75 F
Skydrol 500—300 F

Though most elastomers have poor resistance to gamma irradiation, Viton A seems quite promising after limited testing. Tests were conducted in the presence of diester oil at 400 F. After 10^8 Roentgens exposure, tensile strength is 220 psi and elongation is 120%.

Fluoro-polyester

This elastomer is a hexafluoropentamethylene adipate and is expected to be available soon in limited quantities. It has a -98 to 300 F temperature range in fuels; thus it is suitable for use at extremely low service temperatures.

Typical mechanical properties are shown in Table 20. Tensile strengths of most compounds range from above 2000 psi to as high as 3000 psi. Corresponding elongations range from 100 to 300%.

Typical of fluoro-polyester rubber's resistance to elevated temperatures are the results of aging in air for 168 hr at 400 F a stock with an original tensile strength of 2000-2200 psi and elongation of 110-150; after aging, tensile strength was 1400-1600 psi and elongation was 130-175%.

Little change in tensile strength or other physical properties occurs after immersion for 168 hr in various fluids at room temperature (see Table 23). Of all fluids tested, aromatic gasoline causes the greatest swelling—about 10 to 20%, depending on compounding. Both JP-4 jet fuel and synthetic diester oil cause slight swelling, and 10% hydrochloric acid and salt solutions scarcely affect the rubber. After 70-hr immersion at 350 F in Plexol 201 diester oil, a stock with tensile strength of 2000-2200 and elongation of 110-150% retains tensile strength of 1500-1700 psi and elongation of 150-200%.

References

In preparation of this article the book *Synthetic Rubber* (John Wiley & Sons, Inc., 1954), edited by G. S. Whitby, and prepared under the auspices of the Division of Rubber Chemistry, American Chemical Society, was of invaluable assistance, as was the series of papers delivered before the Southern Ohio Rubber Group of the ACS Division of Rubber Chemistry (Sept-Nov '56), including:

Daum, G. A., "Special Purpose Synthetic Rubbers."
Farynyk, D., "Butyl Rubber."
Gillette, H. G., "Oil Resistant Rubbers."
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Monsanto Chemical Co.
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Texas-U.S. Chemical Co.
Thiokol Chemical Corp.
U.S. Rubber Co.

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Chromium Electroplates

TYPES OF PLATES

Chromium electrodeposits consist of two principal types: decorative and hard chromium plates, and their modifications. Both principal types are deposited from the same plating baths and are distinguishable only by their different thicknesses.

Decorative chromium. Decorative plates are quite thin (0.01-0.02 mil), are usually deposited over a nickel plate, and are used primarily because of their bright, nontarnishing finish.

Some typical applications of decorative chromium plate are: automobile trim and hardware, plumbing fixtures, household appliances and hardware, sanitary fixtures, tools and jewelry.

Hard chromium. These coatings are comparatively thick (0.1 to 15 mils) and are used primarily in engineering applications because of their extreme hardness, low coefficient of friction, chemical resistance, and nongalling and nonwetting properties. Undercoats of nickel or copper are sometimes used for added corrosion resistance.

Applications of hard chromium plate are quite extensive. Some principal applications are gages, tools and machine tool parts—both new parts and worn parts to be salvaged. Taps, drills, saws, milling cutters and burnishing tools have been successfully plated. Molds for plastics and rubber are plated to reduce wear and sticking and to improve product appearance. Gun barrels, pump shafts, engine cylinders, drawing dies, calender rolls and engraving dies are other applications.

Porous chromium. This type of plate is essentially a hard chromium plate containing carefully controlled pits or channels designed to improve the lubrication properties of bearing surfaces. Plates range in thickness from 3 to 15 mils. Beneath its outer surface the plate is no more porous than ordinary hard chromium plate.

Porous chromium plate consists of three principal types: mechanical, pit and channel. The mechanical type is produced by hard chromium plating and subsequently polishing a roughened, cut or engraved basis metal. The polished tops of the grains form the bearing surface and the depressions between the grains hold the lubricating oil. The pit and channel types are produced by chemical or electrochemical etching of the chromium deposit. Plating conditions are controlled to produce latent chromium deposits predisposed to the development of a particular size and type of network pattern during etching.

The pit or pocket type of porous plate is generally used on diesel engine cylinders and industrial gasoline and gas engines, pumps and compressors. The channel type of deposit is generally used on aircraft cylinders. Thickness and porosity of both types of deposits depend on the size and type of engine.

Crack-free chromium. Crack-free plates, deposited in self-regulating baths, have recently achieved considerable importance. These plates have two principal advantages: 1) their dense, uniform, crack-free structure provides excellent resistance to corrosion and thermal shock, and 2) self-regulation of the bath practically eliminates maintenance problems. In many applications the coating can be deposited directly on the basis metal without prior nickel or copper plating. Deposits are producible in a bright or gray, matte finish. Applications for crack-free plate are generally the same as for decorative and hard chromium plates.

PHYSICAL AND MECHANICAL PROPERTIES

Density, lb/cu in.	0.25
Melting Point, F	3452
Ther Cond, Btu/hr/sq ft/°F/ft	157.3
Specific Heat, Btu/lb/°F	0.1039
Coef of Ther Exp, per °F	14.6×10^{-6}
Reflectivity, %	
Visible Light	62-72
Ultraviolet Light	55-70
Infrared Light	62-88
Elec Resistivity (82 F), microhm-cm	
As Deposited	50-60
After Annealing	13
Hardness (Brinell)	1000 max
Sliding Coef of Friction	
Cr-Plated Steel vs Cr-Plated Steel	0.12
Cr-Plated Steel vs Babbitt	0.13
Cr-Plated Steel vs Steel	0.16

BASIS METALS PLATED

Aluminum and its alloys
Copper and its alloys
Iron and steel
Magnesium alloys
Nickel and its alloys
Titanium and its alloys
Zinc and its alloys

TREATMENT AFTER PLATING

Recent work indicates that heat treatment may not be desirable in applications where fatigue is a factor. In some applications, however, heat treatment may be required to relieve strains caused by occluded hydrogen. For example, hardened high carbon steel parts of thin cross section, such as steel tools, generally require heat treatment after plating. Parts are placed in an oil bath or oven at 250-350 F for 1 to 3 hr. Immersion in boiling water for extended periods has also proved effective.

(continued on p 153)

◄ For more information, Circle No. 568

UNICHROME

Trade Mark

News about

COATINGS for METALS

Metallic..........Organic..........Decorative..........Protective

New type chromium plate improves products

Why Crack-Free Chromium gives superior finish

Regular chromium plate develops a network of cracks as it is deposited. Through these defects, corrosives reach the underlying metal. Deposits from the Unichrome Crack-Free Chromium Plating Process remain structurally sound and continuous. This explains the wide difference in degree of corrosion protection obtained.

OTHER PROPERTIES

Crack-Free Chromium also provides:

1. Increased ductility, so that expansion and contraction cause no cracks.

2. Improved non-galling, non-seizing properties.

3. Low friction, resistance to wear.

4. Hardness (500 to 700 Knoop).

5. Excellent leveling action to help cover surface irregularities and reduce grinding needs.

6. Protection to the base metal without undercoats.

7. A satin matte *decorative* finish that can be applied directly to zinc die casting as well as steel. It buffs readily to high luster.

Bulletin CFC-2 gives more details on self-regulation and other features.

Unichrome is a trademark of Metal & Thermit Corp.

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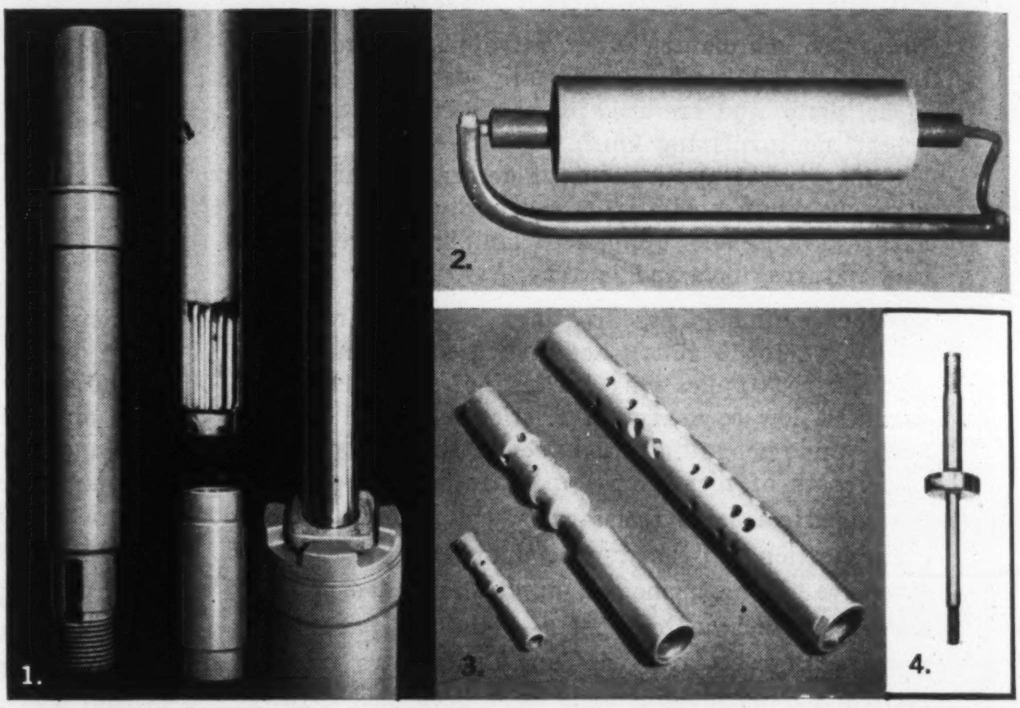

A few of the applications where Unichrome Crack-Free Chromium can be used to protect against corrosion, heat, wear. (1) Washer shafts and sleeve; hydraulic ram. (2) Roller. (3) Hydraulic control valve plungers. (4) Component part of power producing mechanisms.

Difficult problems created by heat, wear, corrosion solved by Crack-Free Chromium

Field reports confirm that Unichrome Crack-Free Chromium is truly a new type of chromium plate with valuable characteristics. It is being used in applications once thought impractical for chromium or other deposits.

IMPROVING HYDRAULIC SYSTEMS

On hydraulic rams, power steering shafts, hydraulic jacks being plated with Crack-Free Chromium, relatively thin deposits protect against corrosion, reduce friction and wear. Where aqueous hydraulic fluid penetrated the cracks in .003 to .005" of ordinary chromium, a .0009" Crack-Free deposit stopped it.

Washing machine and typewriter parts, spline shafts, piston rings, relay armatures are other applications where corrosion problems have been solved.

COMBATING THERMAL SHOCK

Spouts for pouring 2250°F. molten glass into molds last four times longer when plated with Crack-Free Chromium instead of ordinary chromium. Molds for TV tubes, subject to corrosion at the cracks in ordinary chromium, now last 5 to 10 times longer.

Increased ductility combines with resistance to thermal shock for other benefits. Faster, deeper grinding cuts can be made on this new chromium without fracture. On renewed transmission cams, this plate didn't fracture in service, whereas ordinary chromium did on 30% to 40% of the cams.

SLOWING DOWN WEAR

Crack-Free Chromium enables one user to increase life of textile machine rolls by 400% while cutting chromium deposit thickness 95%. It has also increased service life of drills, taps and reamers by 300%, compared with ordinary chromium.

Send for Bulletin CFC-2.

For more information, turn to Reader Service card, circle No. 581

Chromium electroplates—continued

BASIS METAL PRETREATMENT

Decorative plate. In general, bright nickel work that does not require buffing can be placed, still wet, directly in the chromium plating solution. Buffed surfaces, however, must be cleaned to remove grease, dirt and oxide films. Cleaning is performed as follows:

1. Electrolytic alkaline cleaning with basis metal as cathode. Treatment performed at 6-12 v and 175-200 F long enough to remove dirt and grease.
2. Warm water rinse (120 to 160 F).
3. Cold water rinse.
4. Acid dip at room temperature to remove surface oxide. Treatment can be performed in sulfuric acid (20% by vol) solution; in muriatic acid (30-50%) solution; or by using basis metal as cathode (4-6 v) in electrolytic sulfuric acid (5%) solution.
5. Cold water rinse.

Hard chromium plate. Basis metal pretreatment is especially important for hard chromium plates since the coating does not fill in pits and scratches and tends to reproduce the surface on which it is deposited. Though no definite sequence of operations can be given for all types of work, the following pretreatment is typical for ferrous surfaces:

1. Preliminary grinding to remove scale, pits and scratches. (This step is not required for smooth surfaces.)
2. Preliminary cleaning by vapor degreasing or washing in petroleum spirits to remove oil or grease.
3. Electrolytic cleaning in hot alkali cleaner.
4. Cold water rinse.
5. Electrolytic etch to remove light rust and other iron compounds, and to produce a slightly roughened surface that will promote adhesion of chromium. Sulfuric or chromic acids are most commonly used; if shape of parts causes entrapment of sulfuric acid with consequent danger of contaminating chromium plating bath, chromic acid etch may be preferred. Parts may be transferred directly from chromic acid bath without rinsing.

Etching is sometimes produced in chromium plating bath by reversing current so that work is made anodic. After etching (about ½-1 min), current is reversed and plating started. Thin oxide films can also be removed by dipping work in dilute sulfuric or hydrochloric acids. This method does not appreciably dull the luster of highly polished surfaces; however, it does not promote adhesion as well as other etches.

PLATING BATHS

Conventional chromium plating baths contain only two essential constituents: chromic acid and a sulfate catalyst acid radical. Successful deposition is determined by the weight ratio of chromic acid to sulfate; this ratio should be kept between 50:1 and 250:1, preferably at about 100:1. Too small a catalyst content can result in no deposition at all or else produce brown oxide stain. Similarly, too high a catalyst content produces a bath with poor or no throwing power. Two typical formulations are:

Concentrated		Dilute	
Chromic acid (CrO_3)	53 oz/gal	Chromic acid	33 oz/gal
Sulfate	0.53 oz/gal	Sulfate	0.33 oz/gal

The dilute bath has a slightly higher current efficiency than the concentrated bath. However, because of its lower conductivity, the dilute bath usually requires a higher voltage for a given current density. Also, because of its low sulfate content, the dilute bath is more sensitive to the addition or removal of catalyst from drag-in and drag-out.

A self-regulating high speed chromium plating solution is gaining wide acceptance, especially for high production decorative plating using automatic equipment. It consists of a proprietary solution containing mixed acid radicals which automatically regulate themselves. The high cathode current efficiencies and the bright plates produced at high current densities result in high plating rates—more than twice those of conventional solutions, it is claimed.

THICKNESS OF DEPOSITS

In general, thickness of plates for decorative applications ranges from 0.01 to 0.02 mil. Following are some typical thickness recommendations (in mils) for hard chromium deposits:

Drills	0.05-0.5
Reamers	0.1-0.5
Burnishing bars	0.5-3.0
Drawing plugs, mandrels	1.5-8.0
Drawing dies	0.5-8.0
Gages	0.1-1.5
Pump shafts	0.5-3.0
Rolls, drums	0.25-12.0
Hydraulic rams	0.5-4.0
Printing plates (engraved steel)	0.2-0.5

The help of Metal & Thermit Corp. and Van der Horst Corp. in preparing these data is gratefully acknowledged.

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Gain the speed and economy of cold bonding! Fabricate sandwich panels for non-load bearing uses with 3M Adhesive EC-1357.

This high-strength, flexible adhesive bonds sandwich panels without clamps or heated presses. You force-dry the solvent out of the adhesive before bonding. Cold press or nip roller finishes the job. You get maximum immediate strength. And EC-1357 builds up even more strength with age as it cures at room temperatures.

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What's new IN MATERIALS

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Welded aluminum plate *makes up the all-aluminum elevator aboard supercarrier USS Ranger.*

Two New Aluminum Alloys Have Excellent Welding Characteristics

■ Two new aluminum alloys possessing excellent welding characteristics are now available from Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh. The first, designated X5454, is expected to find extensive use for aluminum vessels, storage tanks, tubes and piping required to handle chemicals at elevated temperatures, and for welded tank trailers that transport hot loads such as asphalt.

The alloy (composition: 2.75 magnesium, 0.8 manganese and 0.1% chromium) is said to possess high strength at moderately elevated temperatures, i.e., in the 150-300 F range. Under these conditions, the material offers high resistance to corrosion and stress corrosion in all temper specifications. Welding characteristics o
the alloy are excellent, and tensil
strengths of arc welded joints ar
said to be equal to tensile strengt
of the alloy in the annealed tem
per. Best results are achieved wit
welds made by the inert-gas
shielded consumable arc metho

The alloy is available as shee
plate, tube and extruded shapes.

Best non-heat treatable alloy

Alcoa's second alloy, a new com
position (see table) that is bein
rolled into plate, is claimed t
possess the highest mechanica
properties available in the no
heat treatable alloys. These prop
erties are said to result from th
presence of 5.25% magnesium i
the composition. Typical mecha

New aluminum alloy *is used for one of the world's largest ammonium nitrate storage tanks.*

COMPOSITION OF ALLOY 5456 (%)

Magnesium	5.
Manganese	0.
Copper	0.
Chromium	0.
Aluminum	B

ical properties of Alloy 5456-H321 are: tensile strength, 51,000 psi; yield strength 37,000 psi; and elongation, 16%. The plate is available in thicknesses from 0.280 to 2.0 in. The alloy possesses excellent welding characteristics and can be joined by resistance, tungsten arc or consumable electrode methods. Tensile strength of welds exceeds 42,000 psi. The material is expected to find wide usage in the Navy for gun mounts, carrier elevators, deckhouses and other shipboard installations.

MECHANICAL PROPERTIES OF X5454

Temper ⬇	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong (in 2 in.), %
SHEET AND PLATE			
Annealed	36	17	22
H32	40	30	10
H34	44	35	10
H36	49	40	8
H112	36	18	18
TUBE AND EXTRUDED SHAPES			
Annealed	36	17	22
H112	36	18	18
H311	38	26	14

Strength and ductility offered by . . .

New Titanium Sheet and Bar Alloys

■ Development of three new titanium alloys—a medium strength alloy with good tensile and bend ductility, a high strength alloy with usable ductility, and a high strength alloy with good properties at high temperatures—has been announced by Mallory-Sharon Titanium Corp., Niles, Ohio and Rem-Cru Titanium, Inc., Midland, Pa. The three alloys have in common strength, formability and resistance to creep at elevated temperatures.

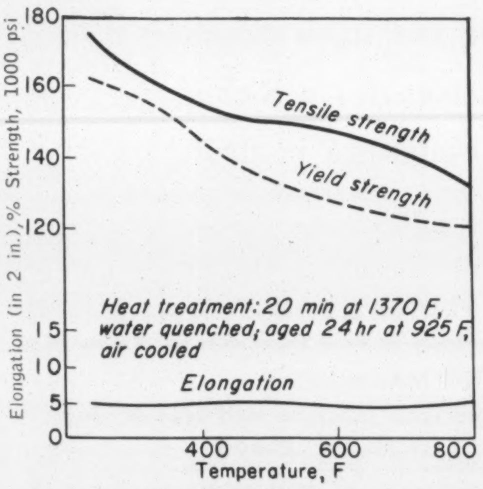


Fig 1—*Effect of temperature on properties of age hardened MST 16V-2.5Al titanium alloy sheet.*

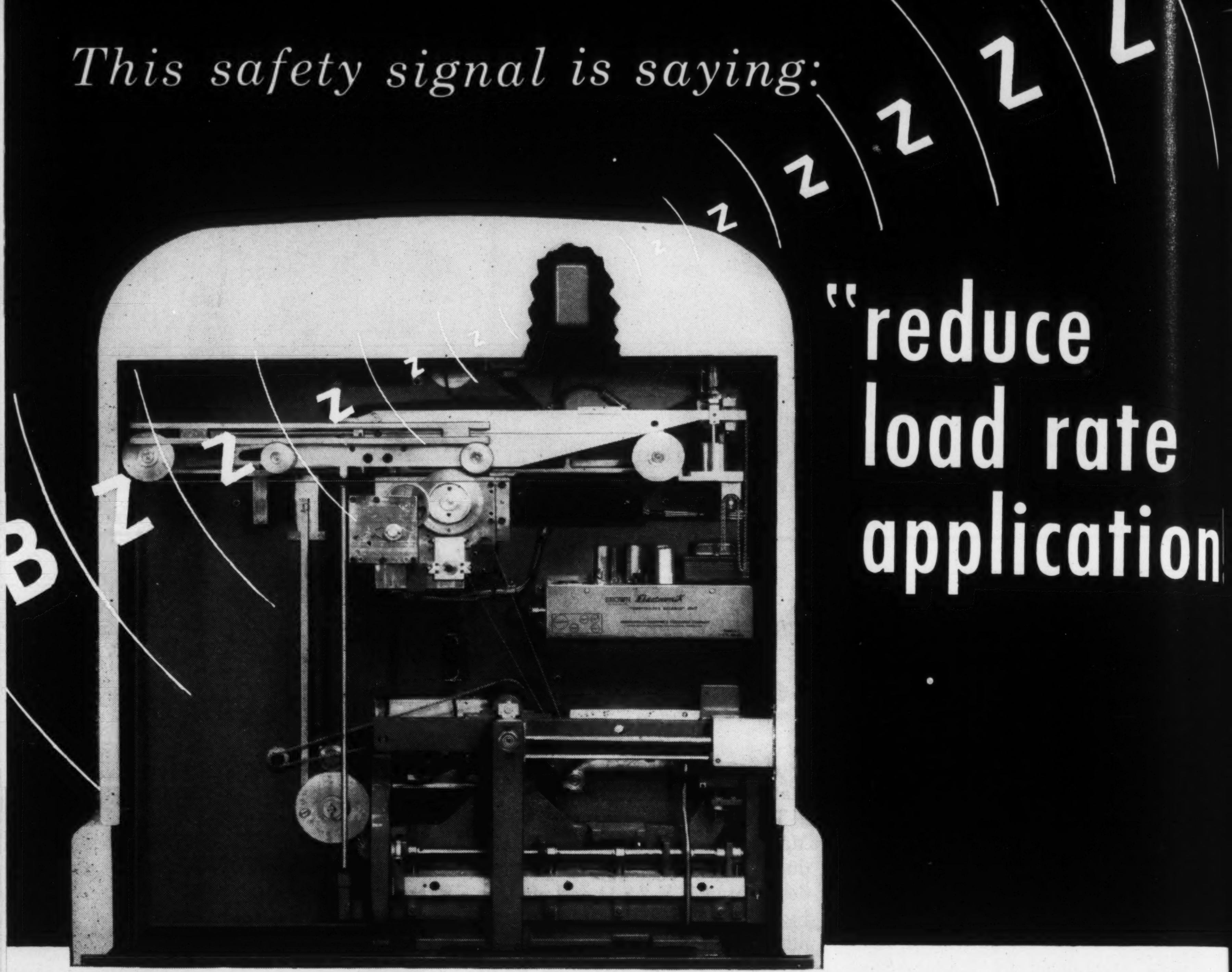
Mallory-Sharon's alloys

The two alloys developed by Mallory-Sharon are being produced as sheet and bar. The first, designated 16V-2.5Al and containing 16 vanadium and 2.5% aluminum, was developed to fulfill requests from the airframe industry for a sheet alloy that would be soft and formable in the solution treated condition and could be age hardened after forming to high strength with usable ductility. It is a highly beta-stabilized alloy that can be solution treated to a tensile strength as low as 110,000 psi and a yield strength of 50,000 psi, with 16% elongation and 1 to 2 T_R (minimum bend radius). It can be subsequently age hardened to a tensile strength of 165,000 psi and a yield strength of 150,000 psi, yet retain 5% elongation.

As shown in Fig 1, the age hardened sheet has good short time hot strength up to 800 F. At 800 F, yield strength is approximately 100,000 psi; above 800 F, strength decreases rapidly with temperature. As age hardened bar, the new alloy was subjected to 50,000 psi load at 800 F for 165

Jet engine compressor blade *forged from Rem-Cru's new alloy.*

This safety signal is saying:



"reduce load rate application

A test reading taken now would probably be erroneously low — or the machine might be running dangerously overloaded.

That's why Riehle's Electro-Balanced indicating unit always *buzzes a warning when a load is being generated on the specimen at a higher rate than a servo system can follow.*

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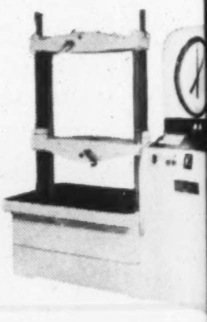

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hr. Room temperature mechanical properties of the bar before and after creep exposure are shown in Table 1. These results indicate satisfactory thermal stability, but low creep resistance at 800 F. At temperatures below 700 F and stresses below 40,000 psi, creep deformation of less than 1% in 150 hr may be anticipated.

According to Mallory-Sharon, the alloy seems to offer considerable promise in applications where a combination of severe forming capability and high aged strength are prime requirements. The alloy is presently under study in the Dept. of Defense Sheet Rolling Program.

TABLE 1—CREEP STABILITY OF AGE HARDENED 16V-2.5A1 ALLOY BAR[a]

Property ↓	Before Exposure	After Exposure
Tensile Strength, 1000 psi	166.9	173.7
Yield Strength (0.2% offset), 1000 psi	150.7	167.6
Elongation (in 1 in.), %	12.5	9.0
Reduction of Area, %	50.7	32.7

[a] 50,000 psi at 800 F for 164.5 hr.

TABLE 2—MECHANICAL PROPERTIES OF MST 821 SHEET AND BAR

Form ➡	0.040-In. Sheet[a]	⅝-In. Bar[b]
Ten Str, 1000 psi	127	130
Yld Str (0.2% offset), 1000 psi	120	123
Elong, %	16.0[c]	16.0[d]
Red. of Area, %	—	38.0
Min Bend Rad. (T_R)	3.5-4.0	—
Charpy Impact Str, ft-lb	—	45.0
Mod of Elast, psi	17 x 10^6	17 x 10^6

[a] Annealed 20 min at 1650 F, air cooled.
[b] Annealed 1 hr at 1650 F, air cooled.
[c] In 1 in.
[d] In 2 in.

The second new Mallory-Sharon titanium alloy, MST 821, is being produced as sheet and bar and contains 8 aluminum, 2 columbium and 1% tantalum. The presence of tantalum and columbium in small quantities permits a higher tolerance for aluminum than does any other alloying addition. Furthermore, since tantalum is an almost neutral solute and columbium is a very slight beta stabilizer, both elements produce only a slight response to heat treatment and no hardenability in the alloy. As a result, the alloy is ductile after welding, retaining its original strength and bend ductility.

The alloy has excellent high temperature properties. At temperatures up to 800 F, times up to 300 hr and stresses up to 50,000 psi, total plastic creep of the alloy is of the order of 0.2% or less. At 1000 F and 50,000 psi, creep is still only 0.2%. Other properties are given in Table 2.

Rem-Cru's alloy

The new titanium alloy developed by Rem-Cru Titanium Corp. has a nominal composition of 6.5 aluminum and 3.75% molybdenum. Called C-130AMo, the alloy is claimed to possess high strength at both room and elevated temperatures. Samples of the new alloy exposed to high stress in the 600-1000 F temperature range show undiminished strength and excellent ductility in subsequent room temperature tensile tests. Tensile strengths exceeding 160,000 psi with good ductility in heat treated sections over 2 in. thick have been achieved in the laboratory (see Table 3).

TABLE 3—MECHANICAL PROPERTIES OF C-130AMo

Form ↓	Ten Str, 1000 psi	Yld Str, (0.2% offset), 1000 psi	Elong (in 2 in.), %	Red. of Area, %
Small Diameter Rod	155-170	145-155	13-18	30-45
Bar (3 x ½ in., longitudinal)	160-163	151-157	15-19	41-44
Bar (3 x ½ in., transverse)	170-181	160-168	12-17	38-43
Billet Slices (>6 in. dia. transverse)	140-150	130-140	8-15	15-30

According to Rem-Cru, the new alloy offers the following advantages over existing alloy grades:

1. Improved elevated temperature strength. (Fig 2 compares short time yield strengths and tensile strengths of the new alloy with those of alloys containing only aluminum or aluminum plus vanadium.)
2. Excellent time-temperature-stress stability.
3. Deep hardenability and excellent heat treated properties.

According to Dr. Walter L. Finlay, vice president and research manager for Rem-Cru, the new bar and forging alloy shows promising properties for jet engine disks and blades, high strength-light weight airframe forgings, airframe fasteners and other parts. Although the alloy is not yet in commercial production, Rem-Cru is offering it on an experimental basis.

(more What's New on p 161)

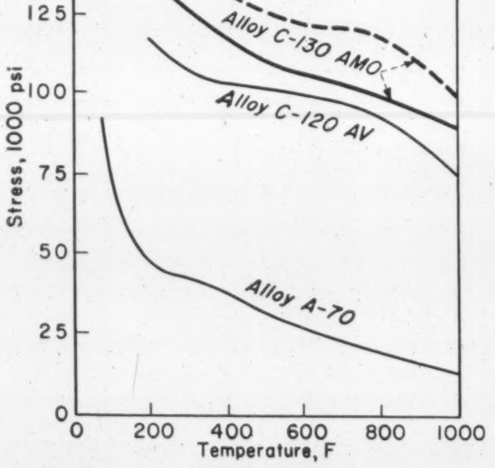

Fig 2—*Elevated temperature strength of titanium alloy C-130AMo compared with that of two other titanium alloys.*

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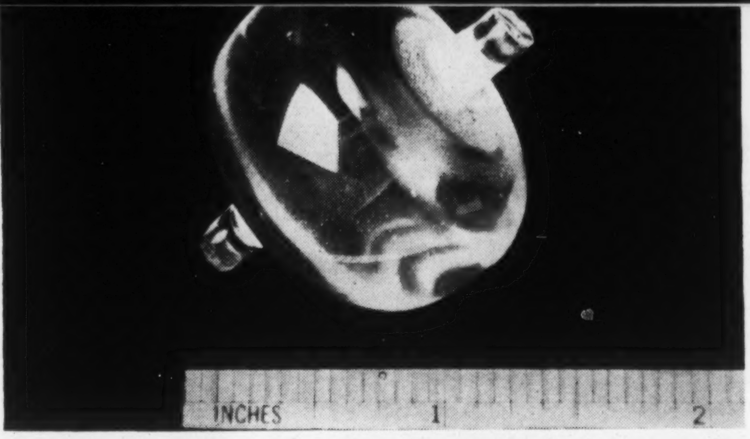
Crystal clear disk *(left) is 175 carats of synthetic sapphire and sells for about $135.*



Large sapphires *now can be synthesized by an improved growing process.*

Better growing techniques make . . .

Synthetic Sapphires Competitive with Sintered Aluminas, Quartz

■ Synthetic sapphires, first made around 1910 by a Frenchman named Vereuil, are one of the most stable metal oxides known. They are extremely hard (next to diamond), strong at high temperatures, abrasion resistant and resistant to most acids and alkalis even at high temperatures. First used in watches during World War II, synthetic sapphires are currently being used in guided missiles, industrial automation instruments, medical equipment, lamps and high temperature measuring devices.

Recently, Linde Co. Div., Union Carbide Corp., 30 East 42nd St., New York 17, announced the development of improved synthetic sapphire growing techniques that produce large single crystals competitive in price with sintered aluminas and quartz. For instance, a large disk 3 in. in dia and ⅛ in. thick costs about $135. A rod 1/5 in. in dia costs about $1.40 per inch of length, and a ball ⅝ in. in dia costs $16.20.

How They're Made

Synthetic sapphires are made by dropping fine particles of aluminum oxide onto a small pedestal in a furnace. These droplets crystallize as they hit the cooler part of the furnace and build up like stalagmites in a cave. The process creates a shape about the size of a man's thumb that can be fabricated into suitable shapes.

The synthetic sapphires are available in the form of windows, rods, tubing, boules and special shapes.

Fabrication

Although procedures for joining sapphire to metals and glass allow the fabrication of intricate devices, complicated sapphire shapes are to be avoided. It is possible to bend small sapphire rods into a variety of shapes, but large rods cannot be bent.

According to the producer, two precautions must be taken in the use of synthetic sapphires. First, sapphire is extremely hard, and its resistance to impact and highly localized stresses is lower than that of most metals. Secondly, large temperature gradients in the sapphire should be avoided and the design of the apparatus in which it is to be used must be such that excessive thermal stresses are not developed in the sapphire. With suitable design, however, sapphire can be used under rugged conditions.

An electron arc method of sealing a sapphire window to glass has been developed, and a gold-nickel alloy of low vapor pressure has been used successfully to bond sapphire to molybdenum sheets.

Applications

Synthetic sapphires are finding wide use as an optical material for lenses, and are particularly good for windows in absorption cells and as entrance and exit windows for optical systems. A flash lamp made with a cylindrical synthetic sapphire rod shows promise as a short wavelength photochemical source. Although the lamp has been flashed more than 3000 times, the resistance of the sapphire to electrical discharge and ultraviolet radiation is good.

Because the material can accurately transmit infrared rays to measuring devices, it is being used in instruments that guide an anti-aircraft missile to an enemy plane on the heat given off by the plane's engines. Sapphire's transparency in the infrared portion of the spectrum is better than that of quartz.

Other uses of synthetic sapphires are in instruments that instantaneously analyze chemicals flowing through a pipe and in temperature sensing devices that measure temperatures up to 3500 F.

(more What's New on p 162)

PROPERTIES OF SYNTHETIC SAPPHIRES

Melting Point, F	3700
Knoop Hardness	1765
Specific Gravity	3.98
Porosity, %	0
Compressive Strength (77 F), psi	300,000
Young's Modulus, psi	53×10^6
Specific Heat, Btu/lb/°F	0.18
Dielectric Strength, v/mil	480,000
Dielectric Constant (300 mc)	10.6

◀ For more information, Circle No. 430

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Materials
Selection

A few months ago, they gave you this new project: design a bearing mount — make it light yet strong and rigid.

To do this job, you had to select a special alloy. No experience or history available on this material for this application — you couldn't be sure the selection was really correct. You designed the part... gave it to the foundry. When you got it back, you could see that they had done a fine job, but you had to be sure. Playing it smart, you sent it to United States Testing Company for evaluation: Tensile — Impact — — Grain Structure — X-ray — a complete treatment. Now you are reading the report. You can relax. United States Testing Company has established just how good the new bearing mount really is.

This is a typical situation in which United States Testing Company, with its complete laboratory facilities, can provide a quick scientific service on new applications.

Why not call or write us today on any material problems you may have. Establish at the design level the strength or weakness of your new product.

UNITED STATES
TESTING COMPANY, INC.
ESTABLISHED 1880
1600 Park Avenue, Hoboken, N.J.
BOSTON • BROWNSVILLE
DALLAS • DENVER • LOS ANGELES
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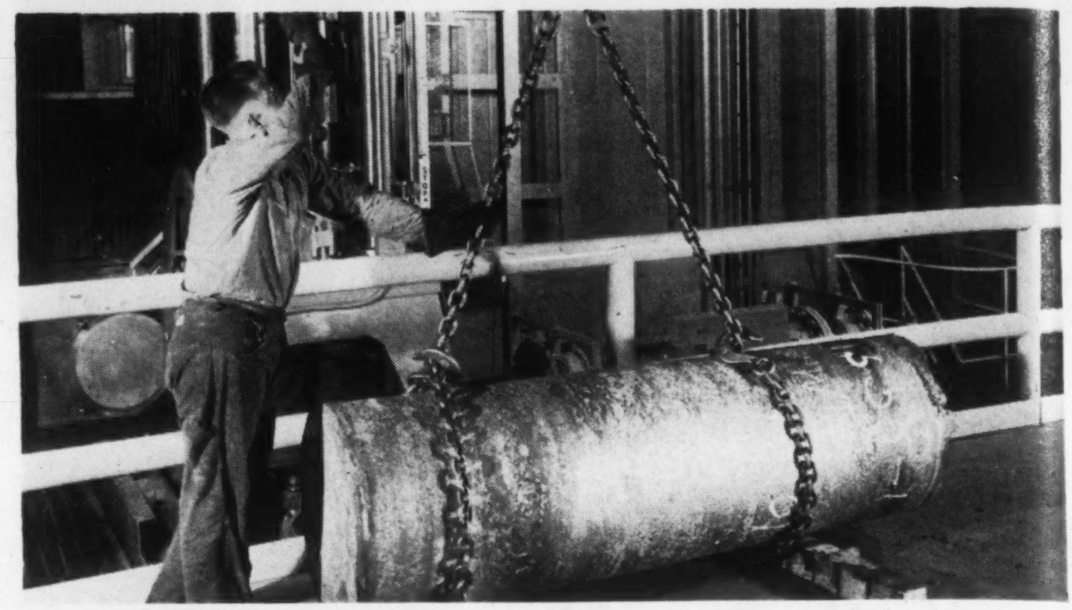


***Heaviest superalloy** ingot ever produced.*

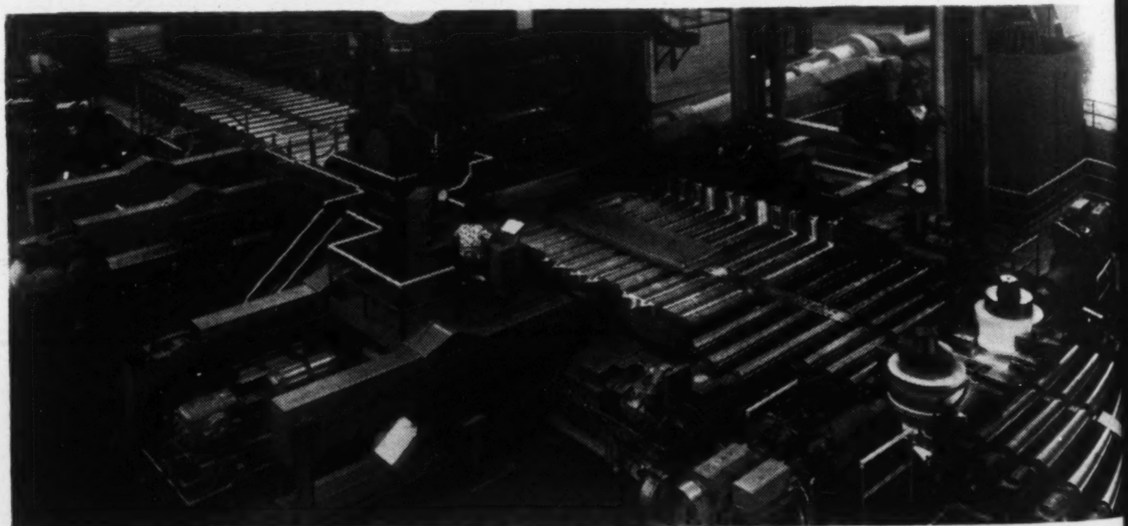
Bigger Superalloy Parts Possible

■ What is believed to be the world's largest furnace for melting high purity superalloys under vacuum has been placed in operation by Allegheny Ludlum Steel Corp.

The new furnace, using the consumable electrode remelting process, is capable of producing 26-in. dia ingots weighing up to 12,000 lb—believed to be the heaviest ingots ever produced by any vacuum melting process (see photo). As a result, such components as gas turbine wheels, landing gear parts for jet transports, and retainer rings for steam turbine generators can be made of superalloys in larger sections of greater strength and dependability.

(more What's New on p 164)

What's new IN MATERIALS



Large aluminum plate—Shown above is what is claimed by Aluminum Co. of America to be the widest hot rolling mill ever placed in operation in the aluminum industry. The new 160-in. mill produces plate up to 6 in. thick, 12 ft wide and 60 ft long.

Other new equipment announced by Alcoa for its expanded sheet rolling facilities include a plate stretcher with a pulling force of 16 million pounds—also claimed to be the largest in the aluminum industry; a 100-in. cold mill for finish rolling wide, coiled sheet; and plate heat treating and aging furnaces large enough to accommodate the 60-ft plates.

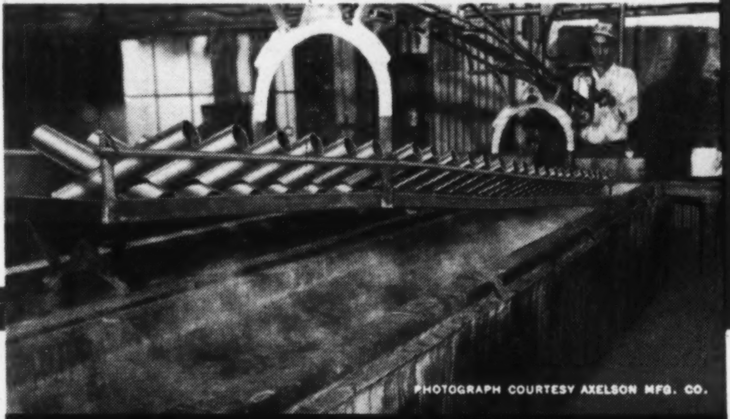
Remove Rust

in 2 SIMPLE STEPS... *without acids*

1. Just DIP...

2. Then RINSE!

with Turco Alkaline Rust Remover



PHOTOGRAPH COURTESY AXELSON MFG. CO.

Here's a single-tank process that *completely obsoletes* conventional methods of removing rust, paint and primer. With Turco Alkaline Rust Remover, you just *dip*, then *rinse!* That's all there is to it!

An easy-to-handle, powdered material, Turco Alkaline Rust Remover normally strips slightly pitted rust in less than a minute. Heavy rust and multiple paint layers require only a few minutes' immersion. Turco Alkaline Rust Remover requires no after-neutralization... no electrolytic current. It contains no cyanide compounds... emits no corrosive fumes. Moreover, it does not affect dimensional tolerances, cause hydrogen embrittlement, or create any of the other hazards commonly encountered with acids. Since Turco Alkaline Rust Remover actually *decreases* the tendency of metals to re-rust, the need for subsequent rust preventive treatments is virtually eliminated.

Turco Alkaline Rust Remover has been thoroughly *proven* in the laboratory... exhaustively *tested* in the field... and *universally accepted by industry!* Check this *new* way... this *better way*... to beat back the problem of rust!

QUICKLY REMOVES TENACIOUS HEAT SCALE, TOO!

Now... with Turco Alkaline Rust Remover used electrolytically, tenacious heat scale can be *quickly* and *completely* removed... with no dimensional loss to the base metal. Moreover, the descaled metal surfaces are exceptionally clean, shiny and free from smut, with a minimum tendency to re-rust.

THE CHOICE IS YOURS!

the obsolete method of rust and paint removal	the TURCO method of rust and paint removal
1. Dip for alkaline degreasing and paint removal	1. Dip for rust and paint removal plus rust prevention
2. Rinse	2. Rinse
3. Acid dip for rust and red oxide removal	
4. Rinse	
5. Neutralize	
6. Rinse	
7. Dry	
8. Dip for rust prevention	

TURCO
ALKALINE
RUST
REMOVER

FREE FOLDER TELLS HOW — Write today for free 4-page illustrated folder describing Turco Alkaline Rust Remover — the *non-acid* compound that quickly removes rust, paint and primer in two simple steps.

TURCO PRODUCTS, INC.

Chemical Processing Compounds

6135 SOUTH CENTRAL AVENUE, LOS ANGELES 1, CALIFORNIA

Factories: Newark, Chicago, Houston, Los Angeles, London, Rotterdam, Sydney, Mexico City, Paris, Hamburg, Montreal, Naha (Okinawa)

Manufactured in Canada by B. W. Deane & Co., Montreal

Offices in all Principal Cities

MAIL COUPON TODAY!

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Please send me free 4-page illustrated folder describing Turco Alkaline Rust Remover

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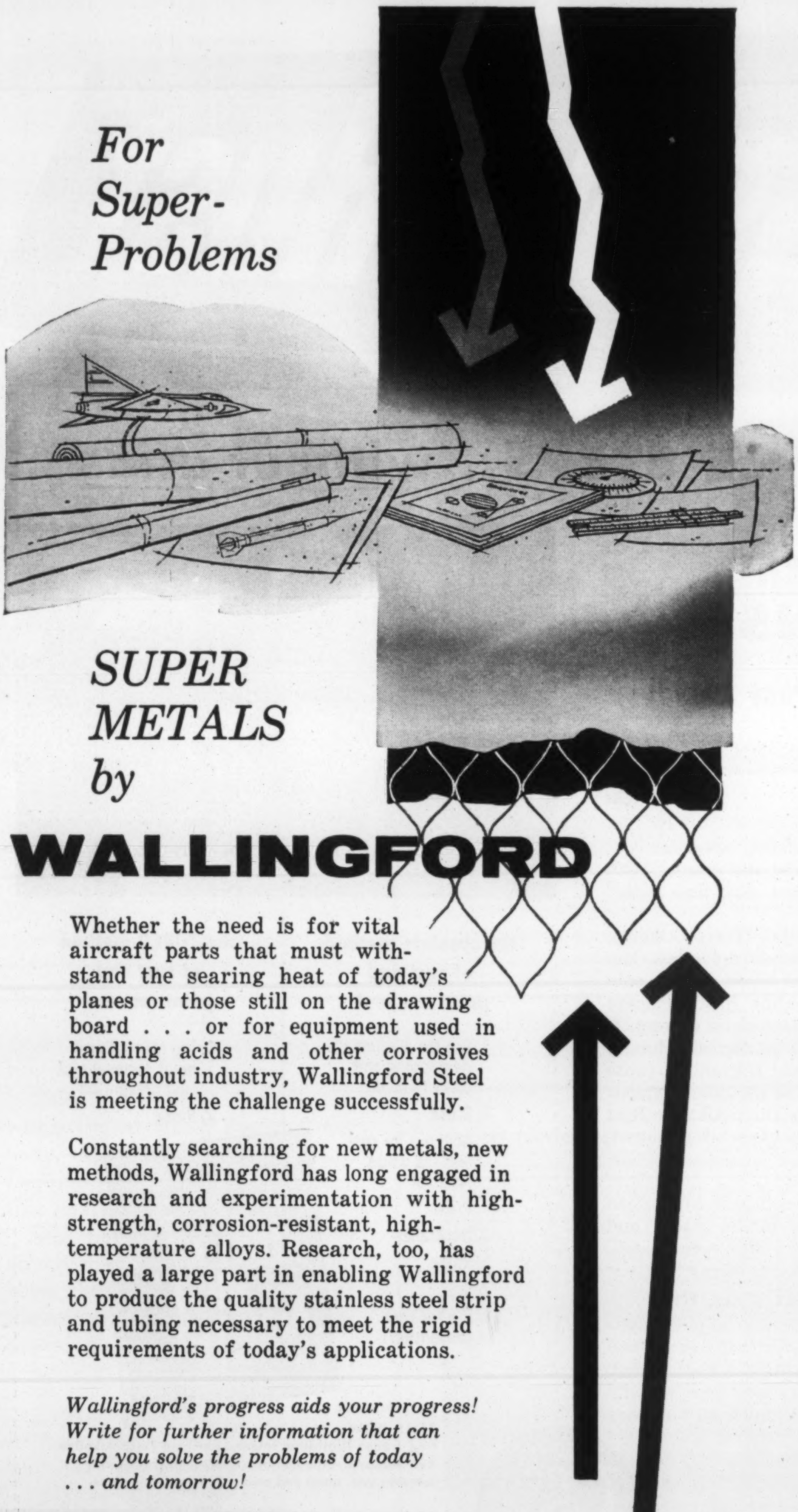
For more information, turn to Reader Service card, circle No. 571



For Super-Problems

SUPER METALS by

WALLINGFORD

Whether the need is for vital aircraft parts that must withstand the searing heat of today's planes or those still on the drawing board . . . or for equipment used in handling acids and other corrosives throughout industry, Wallingford Steel is meeting the challenge successfully.

Constantly searching for new metals, new methods, Wallingford has long engaged in research and experimentation with high-strength, corrosion-resistant, high-temperature alloys. Research, too, has played a large part in enabling Wallingford to produce the quality stainless steel strip and tubing necessary to meet the rigid requirements of today's applications.

Wallingford's progress aids your progress! Write for further information that can help you solve the problems of today . . . and tomorrow!

WALLINGFORD STEEL CO.

THE WALLINGFORD STEEL CO.
WALLINGFORD, CONN., U.S.A.
Progress in Metals for over 35 Years

COLD ROLLED STRIP: *Super Metals, Stainless, Alloy*
WELDED TUBES AND PIPE: *Super Metals, Stainless*

For more information, turn to Reader Service card, circle No. 366

PROPERTIES OF STANPREG

Flexural Strength, psi	
Lengthwise	65,100
Crosswise	61,100
Impact Strength, ft-lb/in.	
Lengthwise	13.25
Crosswise	10.01
Water Absorption, %	0.10
Dielectric Strength, kv	
Parallel-to-Laminations	83.8
Step-by-Step	71.3
Dielectric Constant (1 mc)	4.68
Dissipation Factor (1 mc)	0.0180
Insulation Resistance, megohms	1.8 x 10^7
Arc Resistance, sec	126
Heat Distortion Temp, F	324

Impregnated Glass Cloth in Electrical Uses

An epoxy resin-preimpregnated glass cloth, manufactured by Standard Insulation Co., East Rutherford, N. J., has been designed primarily for use in electrical and electronic applications. Called Stanpreg, the flame resistant, impregnated glass cloth is furnished in dry rolls that are said to be adaptable to sheeting, winding, slitting and other operations.

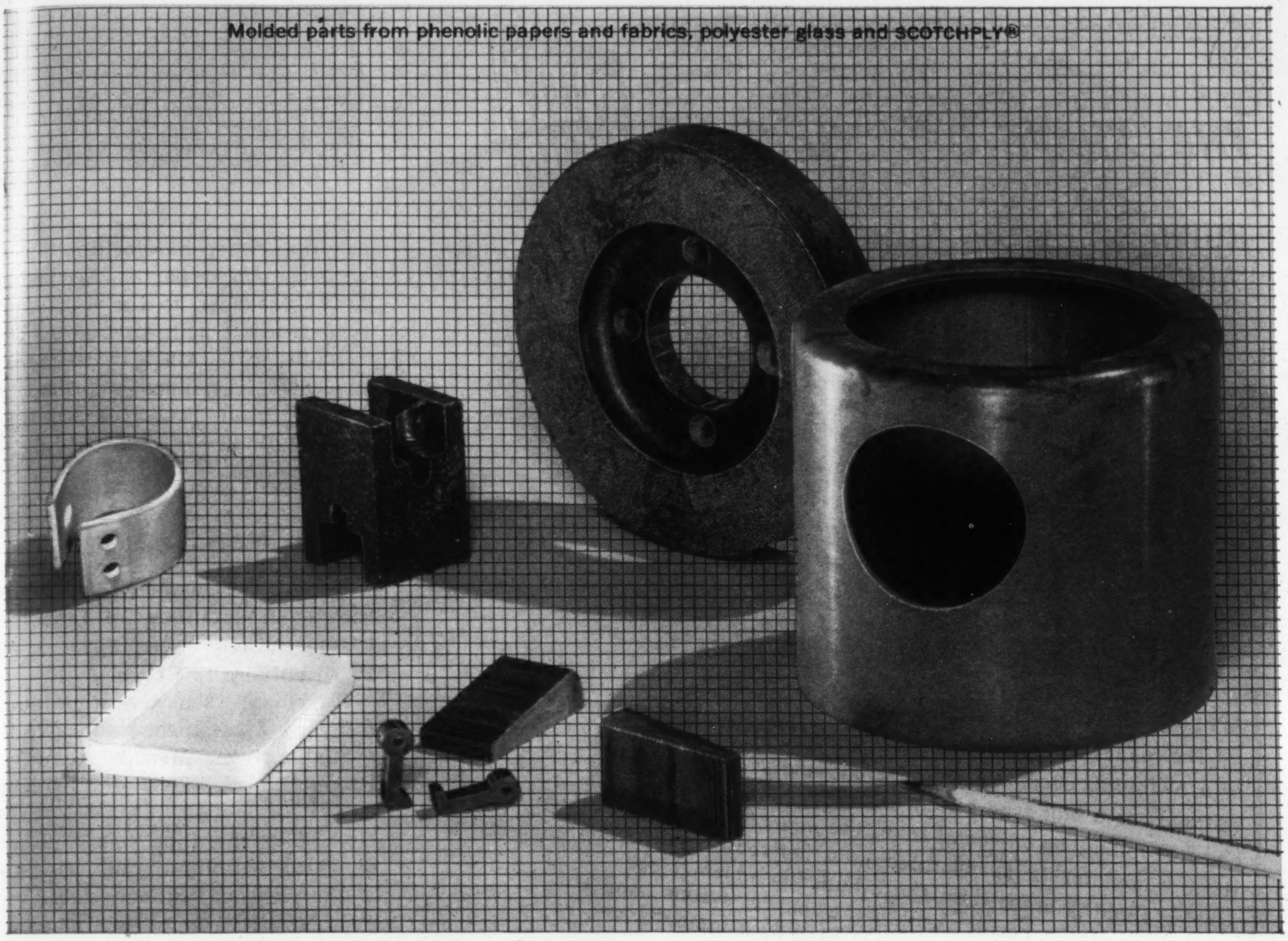
Chromate Finishes for Zinc and Cadmium

Four new chromate finishes are being marketed by Allied Research Products, Inc., 4004-06 E. Monument Ave., Baltimore 5.

Iridite No. 5-P is a powdered concentrate that produces a yellow iridescent coating on zinc and cadmium plate, galvanized iron and zinc die castings. The resultant finish is said to be highly corrosion resistant and to make an excellent base for paint.

Iridite No. 8-4 is an all-purpose liquid chromate for all forms of zinc and cadmium. It is designed to provide a protective coating on zinc and cadmium plate, zinc-base die castings and galvanized steel.

Iridite No. 12-P is a powdered material designed to provide a



Molded parts from phenolic papers and fabrics, polyester glass and SCOTCHPLY®

For better molded laminates…

LET MICA MOLD IT

MICA'S *greater knowledge of materials, molding know-how, ability to vary materials as required, and problem-solving abilities pay off.*

For savings, let MICA mold it. Our knowledge of base materials and molding methods, our undivided responsibility for quality of both materials and workmanship, and our specialized equipment save time and assure consistency, accuracy and prompt delivery.

For special applications, let MICA mold it. Our molding materials include LAMICOID® phenolic papers and fabrics, polyester glass and SCOTCHPLY® epoxy glass. These materials offer light weight, high strength and stability, chemical resistance, insulating properties, heat resistance and low moisture absorption. This wide range of properties meets many different application requirements.

For special processing, let MICA mold it. We are fully equipped to mold parts of intricate shape or difficult contours by matched metal die compression molding. Our facilities include complete fabricating equipment for further machining and finishing of molded parts.

For creative engineering, let MICA mold it. We are prepared to apply our knowledge of base materials, molding and fabricating methods, and application experience to the design and manufacture of prototype or experimental materials and parts.

For prompt quotation on your needs, send us your prints and specifications. We can also supply machined parts from paper, linen, canvas, nylon, asbestos and fibrous glass base materials. A MICA representative will be happy to give you any engineering assistance needed.

SCOTCHPLY® *is a registered trademark of Minnesota Mining and Manufacturing Co.*

MICA INSULATOR COMPANY
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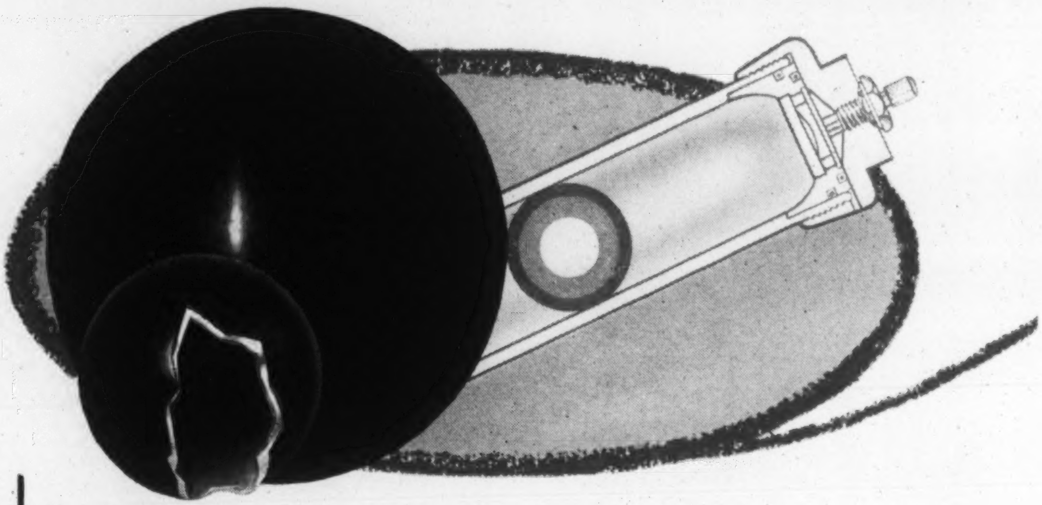
For more information, turn to Reader Service card, circle No. 411

THE SHAPE OF THINGS IN MOLDED RUBBER

RUBBER GETS ON THE BALL VIA "APCOTITE" BONDING AND MOLDING TECHNIQUE



APPLICATION:

The rubber covered aluminum ball shown here is a piston in a hydraulic accumulator of revolutionary design. Advantages of a ball type piston are many. Being spherical and free rolling, no one point takes the wear, and it permits the accumulator to be operated in a horizontal position. Molded slightly larger than the cylinder in which it operates, it creates a perfect seal. The entire system and accumulator were designed and patented by a famous New England engineering firm.

PROBLEM:

Pressure within the cylinder caused the rubber on the sphere to flow and pull away from the aluminum surface of the ball. Customer asked Acushnet to produce a better bond and covering.

SOLUTION:

Acushnet engineers and lab chemists voted not to use pins or location rods of any kind to hold the ball in place while molding but elected to use a preforming mold prior to curing. The final curing of the rubber covering included the use of "APCOTITE," an exclusive Acushnet rubber-to-metal bond. The cross section shown here is proof that a uniform layer of rubber concentrically perfect was obtained on the aluminum insert.

Apcotite bonding to metal is exclusive with Acushnet and provides for high strength bond of rubber, synthetic polymers, silicone and plastics to all metals for the life of the part. Technical assistance at any stage of design is available from the Acushnet laboratories. Send for brochure describing Apcotite bonding in detail. Specify "APCOTITE"!

Acushnet

ACUSHNET PROCESS COMPANY
NEW BEDFORD, MASSACHUSETTS
... *Precision Molded* RUBBER, SILICONES - "APCOTITE" BONDING
Address all communications to 750 Belleville Ave., New Bedford, Mass.

For more information, turn to Reader Service card, circle No. 500

one-dip, clear, blue-bright finish on zinc plated parts. According to the producer, it can be used to replace nitric acid dips.

Iridite No. 14-9 is a powdered concentrate designed to provide a one-dip, clear protective coating for aluminum surfaces.

Three New Tapes

Recent developments in tapes include an aluminum foil tape and two metallized Mylar tapes.

1. Aluminum foil tape

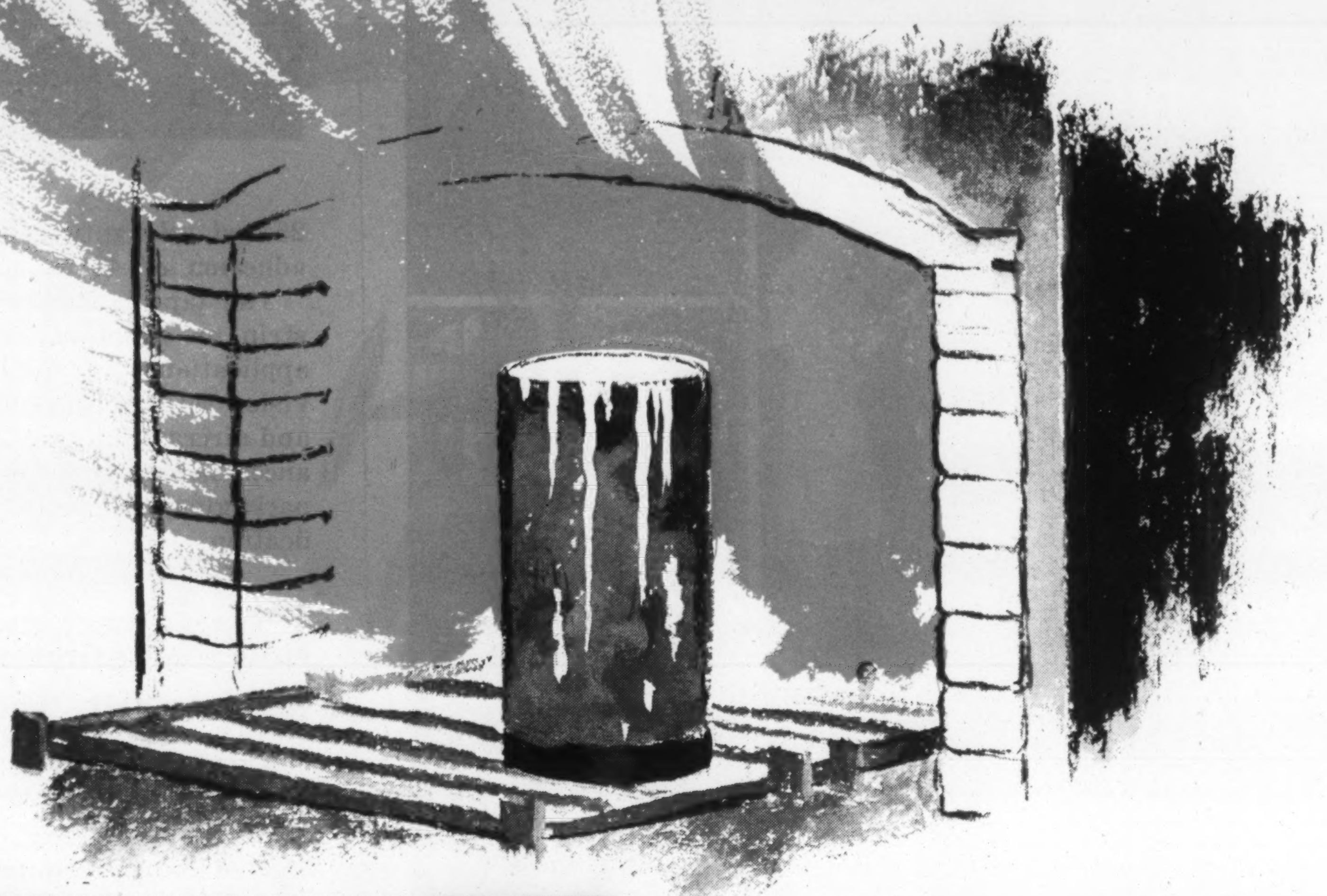
A pressure sensitive aluminum foil tape with silicone adhesive is available from Mystik Adhesive Products, Inc., 2635 N. Kildare Ave., Chicago 39. Called Mystik No. 7402, the tape has a 2-mil annealed aluminum foil backing and a silicone rubber adhesive. Temperature range for the tape is –100 to 550 F. The tape is said to be ideal for aircraft, missile and appliance applications.

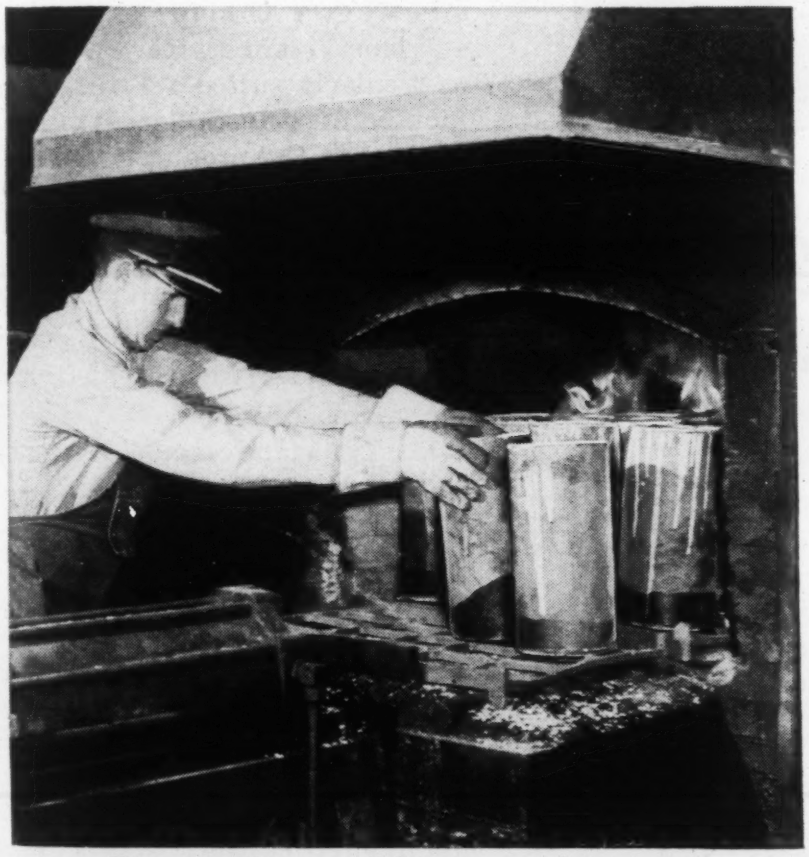
2. Metallized tapes

Two companies have recently introduced metallized Mylar tapes. One company, Coating Products, Inc., Englewood, N. J., is marketing a line of Mirro-Brite metallized Mylar tapes. The tape consists of aluminized polyester film laminated to vinyl, embossed into decorative patterns and combined with a high tack pressure sensitive adhesive. The metallized tape is being marketed in 100-yd rolls in various widths ranging from 5/8 to 1 in. The tape is available in a number of colors.

The other company, Permacel Tape Corp., New Brunswick, N.J., is marketing Permacel EH 3820, a metallized Mylar embossing tape. According to the producer, it can be die cut in an infinite number of shapes and embossed in a variety of different patterns. The backing of the tape consists of 2-mil acetate-butyrate laminated to 0.5-mil metallized Mylar. The tape has a tensile strength of

HAYNES Alloys solve the *tough* heat problems





. . . Entering "burn-out" furnace are investment-casting mold flasks made of MULTIMET alloy. Over 25,000 flasks of many shapes and sizes fabricated from 16-gauge sheet are in daily use.

2000 Hours in 1900-Deg. F furnace

Inside "burn-out" furnaces rows of investment-casting mold flasks reach temperatures as high as 1900 degrees F while under direct flame impingement. Flasks made of MULTIMET alloy operate under these severe oxidizing conditions for 2000 hours. They have survived repeated heating and cooling for 200 trips, each 8 to 10 hours, through the furnace without rupturing or losing their strength.

If you are seeking exceptional service against severe heat conditions, get the complete story on HAYNES alloys. Contact our nearest sales office or write for descriptive literature. Address HAYNES STELLITE COMPANY, Division of Union Carbide Corporation, General Offices and Works, Kokomo, Indiana.

HAYNES
ALLOYS
HAYNES STELLITE COMPANY
Division of Union Carbide Corporation

UNION
CARBIDE

"Haynes," "Multimet" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

For more information, turn to Reader Service card, circle No. 418

25 psi, elongation of 75% and adhesion of 40 to 45 oz per in.

The tape is recommended as a strip or panel material in such applications as radio and television sets, lighting fixtures, auto and aircraft interiors, home appliances, housewares, containers, and packaging and machinery identification.

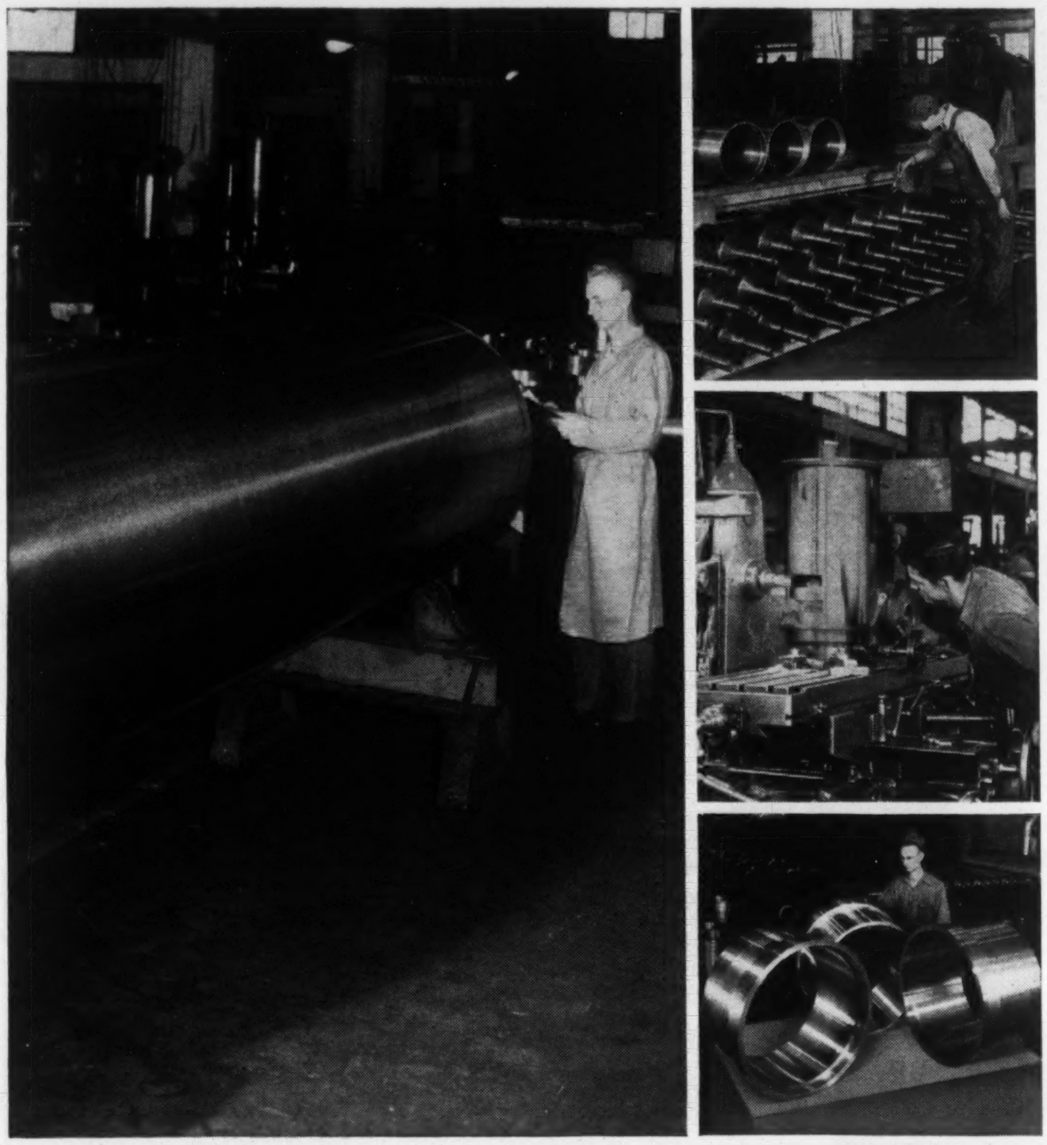
New Polyethylene Pipe Resists Oil, Solvents

Allied Chemical & Dye Corp., 61 Broadway, New York 6, N. Y., recently announced that it has started commercial production of a new form of high density polyethylene resin with properties particularly suited for the manufacture of polyethylene pipe. According to the producer, the process for making the resin is entirely new and does not resemble either the Ziegler or Phillips process. Called A-C polyethylene pipe compound, the high density resin is compounded with carbon black.

Properties of pipe

Plastics pipe made from the resin by Orangeburg Mfg. Co., Inc., Orangeburg, N. Y., and called SP plastic pipe, is said to have high bursting strength, resistance to impact, absence of stress cracking, excellent heat resistance, and resistance to chemicals, organic solvents and hydrocarbon liquids. Forbes Silsby, vice president of Allied Chemical, says that "failure due to environmental stress cracking is entirely overcome in pipe made from this new resin. Also, tests indicate the pipe will be suitable for transmission of solvents and hydrocarbons as in oil and gas fields, a use denied to conventional polyethylene pipe."

According to the producer, the high molecular weight of the resin (> 750,000) imparts to the pipe complete freedom from slitting under severe conditions; greater tensile strength and yield strength,



You'll find them better for pressure if they're

SHENANGO CENTRIFUGAL CASTINGS

WHATEVER the inside or outside pressures, Shenango centrifugal castings are better able to withstand them without failure.

Parts cast by the Shenango centrifugal process are much tougher because their finer, *pressure-dense* grain avoids stress concentrations while providing greater strength, better elongation and freedom from such costly defects as sand inclusions, blowholes and such.

Whether you need rings, rolls, sleeves, liners, bushings, bearings, mandrels or *any* annular or symmetrical part . . . ferrous or non-ferrous . . . in whatever shape, size or dimension to meet your requirements . . . Shenango can do the job. And do the job *better!*

For informative bulletins on the answers to your tough problems, it will pay you to write now to: *Centrifugally Cast Products Division,* The Shenango Furnace Company, Dover, O.

SHENANGO CENTRIFUGAL CASTINGS

COPPER, TIN, LEAD, ZINC BRONZES • ALUMINUM AND MANGANESE BRONZES
MONEL METAL • NI-RESIST • MEEHANITE METAL • ALLOY IRONS

For more information, turn to Reader Service card, circle No. 413

Courtesy: Resistoflex Corp., Roseland, N. J.

How do you keep rocketing at 8000 mph?

For one thing, you feed your rocket fuel – savagely corrosive stuff, like white and red fuming nitric acid. You use a fuel line of Teflon hose, wrapped in stainless wire braid – with special stainless steel fittings to make it stay put.

The fittings are swaged on – and listen to a few of the 19 test beatings they get. In an impulse test, with fluid temperature at 400° F., an impact of 4500 psi is applied, and reduced to zero in one second. The cycle is repeated 35 times a minute – for 100,000 cycles.

Another test, at 450° F., submits the hose and fittings to vibration at 2000 cycles per minute through ¾″ lateral movement. This grueling test is applied for 200 hours . . . is followed by a severe high-pressure test to assure a leak-proof seal. It's hard on the fittings . . . but a positive test of durability.

Frasse has provided trouble-free stainless steel for this vital fitting application since its inception – and often supplied it *in hours*, to meet production deadlines. So, if you want reliability in your product, and a reliable source of supply . . . rely on Frasse for *all* your stainless requirements. It's a habit you'll find profitable.

Call FRASSE for COMPLETE STAINLESS STEEL SERVICE

Bars • Forgings • Sheets • Strip • Plates • Wire • Tubing • Pipe • Fittings • Valves

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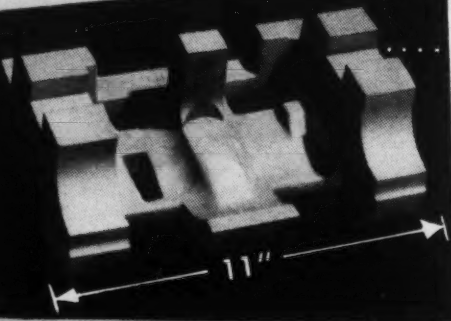
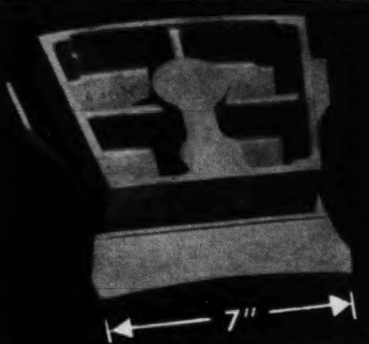
Cast steel component parts offer a wide range of performance advantages when they are

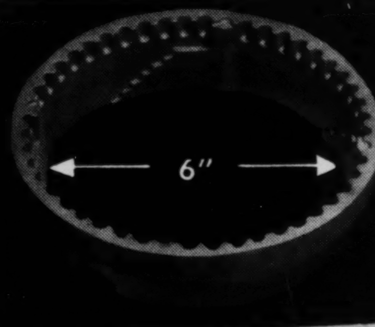
CAST BY LEBANON



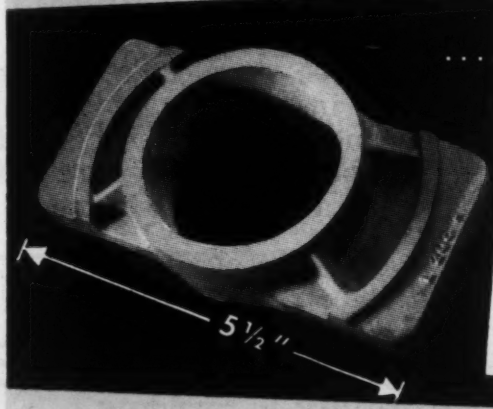
. . . . . performance from casting ACCURACY
Cast by Lebanon for high speed printing presses, this intricate casting (shown as cast) requires virtually no machining. Its dimensional accuracy permits completely efficient operation in close tolerance with its mating parts.



. . . . . performance from casting SURFACE
This bottling cap guide requires a surface accuracy comparable to investment castings. *Cast by Lebanon* in stainless steel, the part goes into operation with no expensive machining. (Shown as cast.)



. . . . . performance from casting INTRICACY
Shredder rings for garbage disposal units substantially reproduce in cast steel the intricacy and accuracy of machined parts. *Cast by Lebanon,* these units are a major production item of the shell mold department.



. . . . . performance from casting INTEGRITY
This aircraft casting for a jet engine bearing housing was *Cast by Lebanon* in low carbon steel for great strength under fatigue stress. Surfaces and dimensions are so accurate as to require virtually no machining and compare favorably with those obtained by investment casting methods.

AVAILABLE TO YOU: Consult our foundry engineers at the initial stage of your design project to best utilize the inherent advantages of CAST STEEL and to benefit from our many facilities and experience in prototype work.

Write for our Design File M

CIRCLE L

LEBANON STEEL FOUNDRY
113 LEHMAN STREET
LEBANON, PENNSYLVANIA
CARBON, LOW ALLOY AND STAINLESS STEEL CASTINGS

For more information, turn to Reader Service card, circle No. 545

PROPERTIES OF A-C POLYETHYLENE

Specific Gravity	0.96
Tensile Strength, psi	3480
Yield Strength, psi	3075
Elongation, %	600
Flexural Strength, psi	3700
Notched Impact Strength, ft-lb/in	12.5
Crystalline Melting Point, F	257
Brittle Temperature, F	Below —120
Coef of Ther Exp, per °F	9×10^{-5}

higher heat and chemical resistance, greater resistance to abrasion and a substantially lower rate of creep than conventional polyethylene pipe has. The plastics pipe is also said to be impervious to electrolytic environment, ultraviolet rays and subzero temperatures.

Uses of pipe

Since the pipe has greater strength than other high density polyethylene pipe, it is somewhat less flexible than pipe made from conventional polyethylene. However, it is said to retain sufficient flexibility to permit coiling and easy laying in the field.

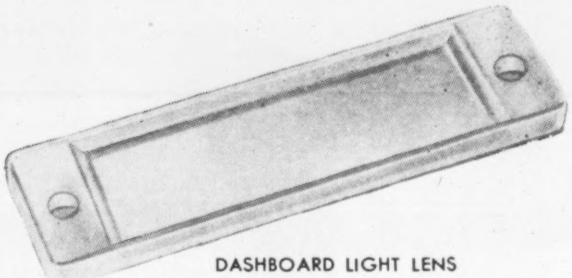
Approved by the National Sanitation Foundation for use in portable water installations, the pipe can be laid over, under and around obstructions and can be cut with a hacksaw.

The high density polyethylene pipe is recommended for jet well, lawn sprinkling and air conditioning installations; piping systems for ice skating rinks; industrial piping; and golf course watering systems.

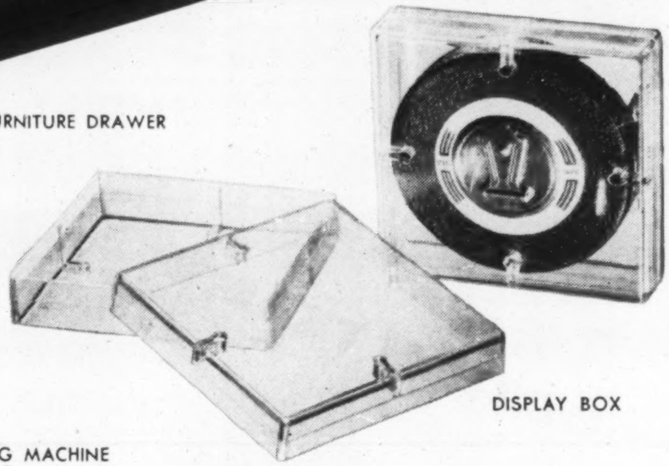
Use of Steel Castings in High Speed Aircraft

Aircraft designers would like to use lots of steel castings in high speed aircraft and guided missiles, but there are certain limitations on their use at present. The most important limitation is a lack of design data, according to Robert J. Ely of American Brake Shoe Co., S. K. Hodgson of Chance

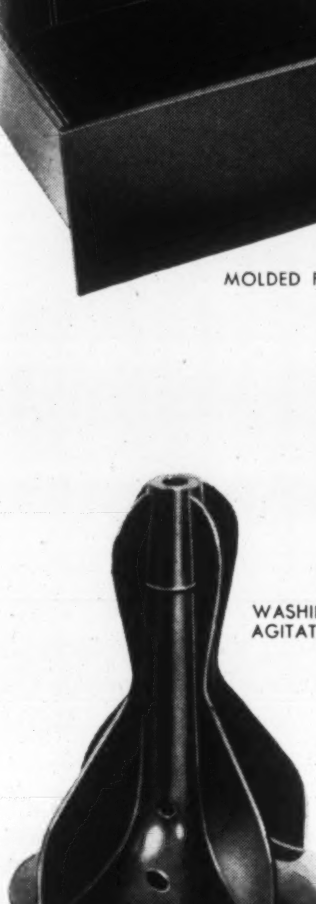
MOLDED FURNITURE DRAWER



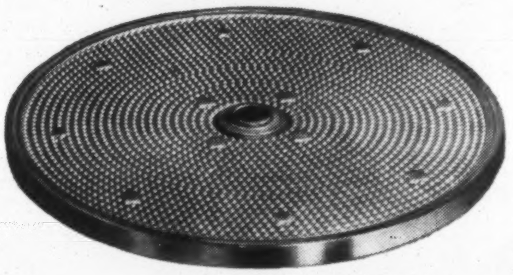
DASHBOARD LIGHT LENS



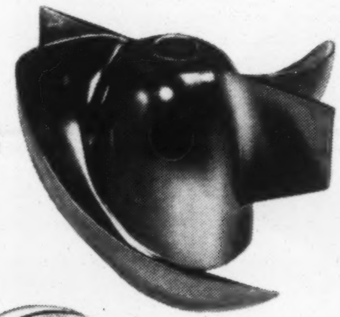
DISPLAY BOX



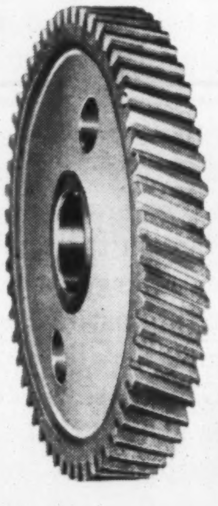
WASHING MACHINE AGITATOR



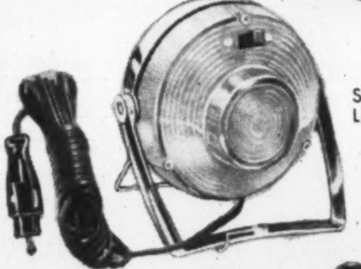
FILTER PLATE



DISHWASHER IMPELLER



TIMING GEAR



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. . . the two-way answer to fastening problems

Here's a combination that slashes production costs and gets rid of fastening problems in a hurry—Milford Rivets made to high-quality standards to assure a better finished product for you . . . Milford automatic rivet-setting machines that can be quickly adapted to your particular fastening needs.

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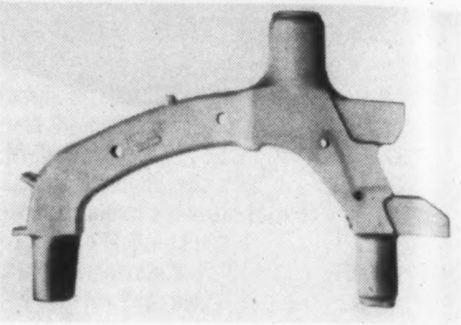


Steel casting *used on aircraft bomb rack must be sound.*

Vought Aircraft, Inc., and John H. Garrett, executive secretary of the Defense Department's Coordinating Committee on Materials.

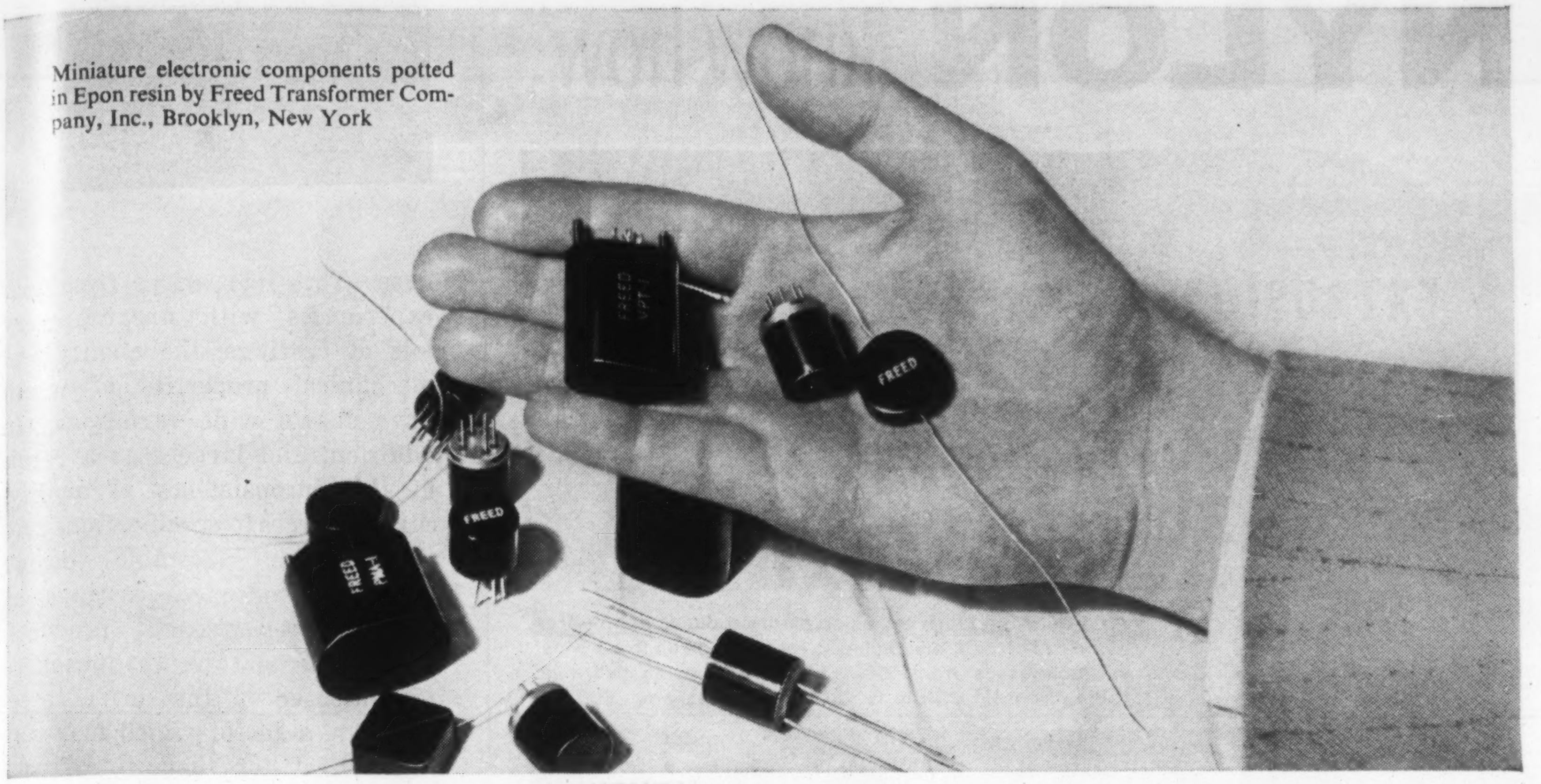
All three men, who spoke at the spring technical meeting of the Investment Casting Institute, believe that establishment of quality standards, improved inspection methods, improved casting and heat treating techniques, and good reproducibility of test results are needed to produce good steel castings in the 180,000 to 200,000 psi tensile strength range. Such castings have a strength-weight advantage over aluminum even at room temperature.

Although there is increasing interest in large castings for use in aircraft, castings are commonly assumed to be "undependable," Mr. Garrett says. However, many people believe that the deficiencies of castings are not necessarily fundamental but may be due to inadequacies in foundry techniques. As a result there has been quite a bit of interest in setting up a program to improve methods of making high integrity castings.

Aircraft castings

One program, conducted by the Materials Advisory Board of the National Research Council, revealed that the use of steel castings in aircraft is less today than during World War II. The gist of the Panel's findings:

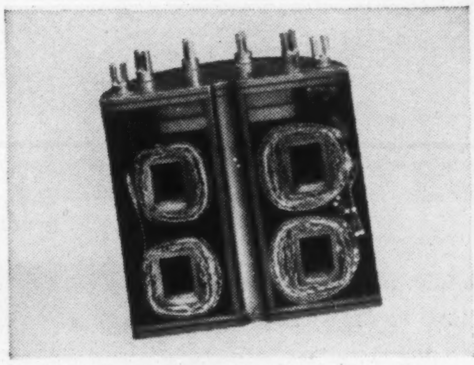
"Aircraft manufacturers are generally hesitant to use steel castings in critical applications because of fear of casting fail-


Miniature electronic components potted in Epon resin by Freed Transformer Company, Inc., Brooklyn, New York

Why EPON® RESINS for potting?

4 Good Reasons!

1. Outstanding adhesion to metal, glass, plastics
2. Excellent dimensional stability
3. High mechanical strength
4. Excellent dielectric properties


Section of magnetic amplifier coils embedded in Epon resin by Westinghouse Electric Corporation, Pittsburgh, Pa.

EPON RESINS are preferred for potting, laminating, sealing and encapsulating because they offer an almost ideal combination of electrical and physical properties.

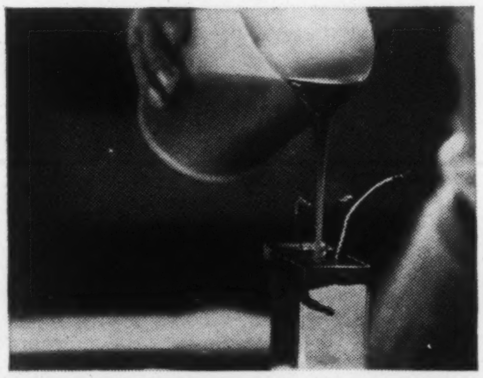
Potting and encapsulating. Epon resins have outstanding adhesive properties. They form strong bonds to metal and glass, provide airtight enclosure of delicate components and vacuum tubes. They also have excellent dimensional stability and can withstand solder bath temperatures.

Sealing. Enamels and varnishes based on Epon resins provide excellent moisture sealing plus outstanding resistance to solvents and chemicals, even at elevated temperatures.

Laminating. Epon resins, laid up with inert fibrous fillers, produce base laminates of superior dielectric properties which can be sheared, punched, drilled and bath soldered.

Adhesives. Solvent-free Epon resin formulations cure at room temperature, with contact pressure alone; form powerful bonds between glass, metal, wood or plastic.

Write for complete information on the use of Epon resins in protective enamels, tool and die materials, etched circuit laminates, transformer and motor sealing compounds.


Potting transformer with Epon resin at PCA Electronics, Inc., Santa Monica, Calif.

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NYLON "know-how"

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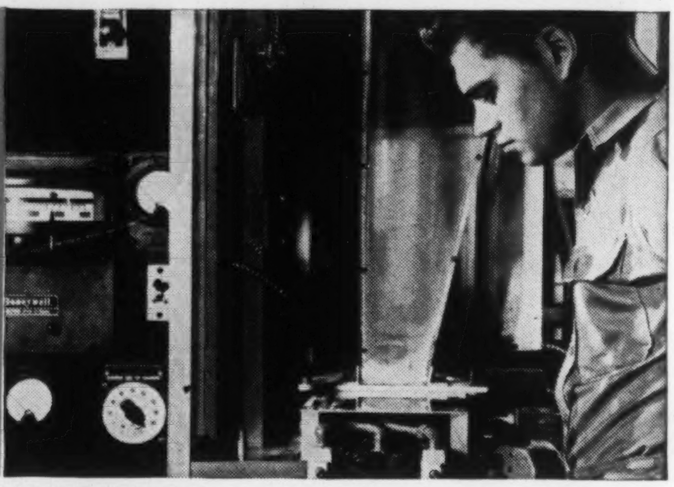
rods, tubing, sheets, tape



A new ultra-modern extrusion plant produces bubble-free nylon rod up to 3" dia.; nylon sheet and tape up to 12" wide, in thicknesses from .002" to 1/8"; and nylon hydraulic tubing from 1/8" O.D. to 1/2" O.D. for 1000 psi and 2500 psi.

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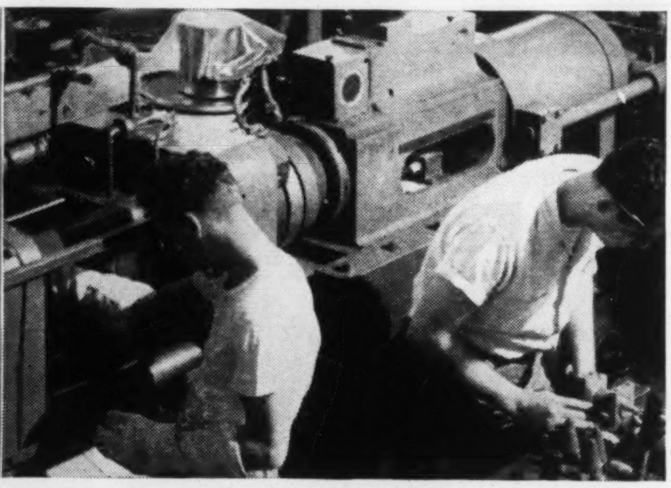
mass produced at low cost



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on high speed automatics

A complete, high-speed plastics machining plant, geared to the production of innumerable nylon parts to manufacurers' specifications. Whatever your nylon part requirements—check your methods and costs with U.S.G. "Know-how."

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Plastics Division
OF THE GARLOCK PACKING COMPANY

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ures. This fear arises from past experiences with unsatisfactory lots of castings, the quality and mechanical properties of which have shown wide variations. In addition, and largely as a result of this inconsistency of quality, current aircraft specifications provide lower allowable design strengths for steel castings as compared to wrought products. Thus, size and weight penalties are imposed in the use of steel castings, a factor which makes it impractical for them to be considered for most aircraft applications."

Casting design

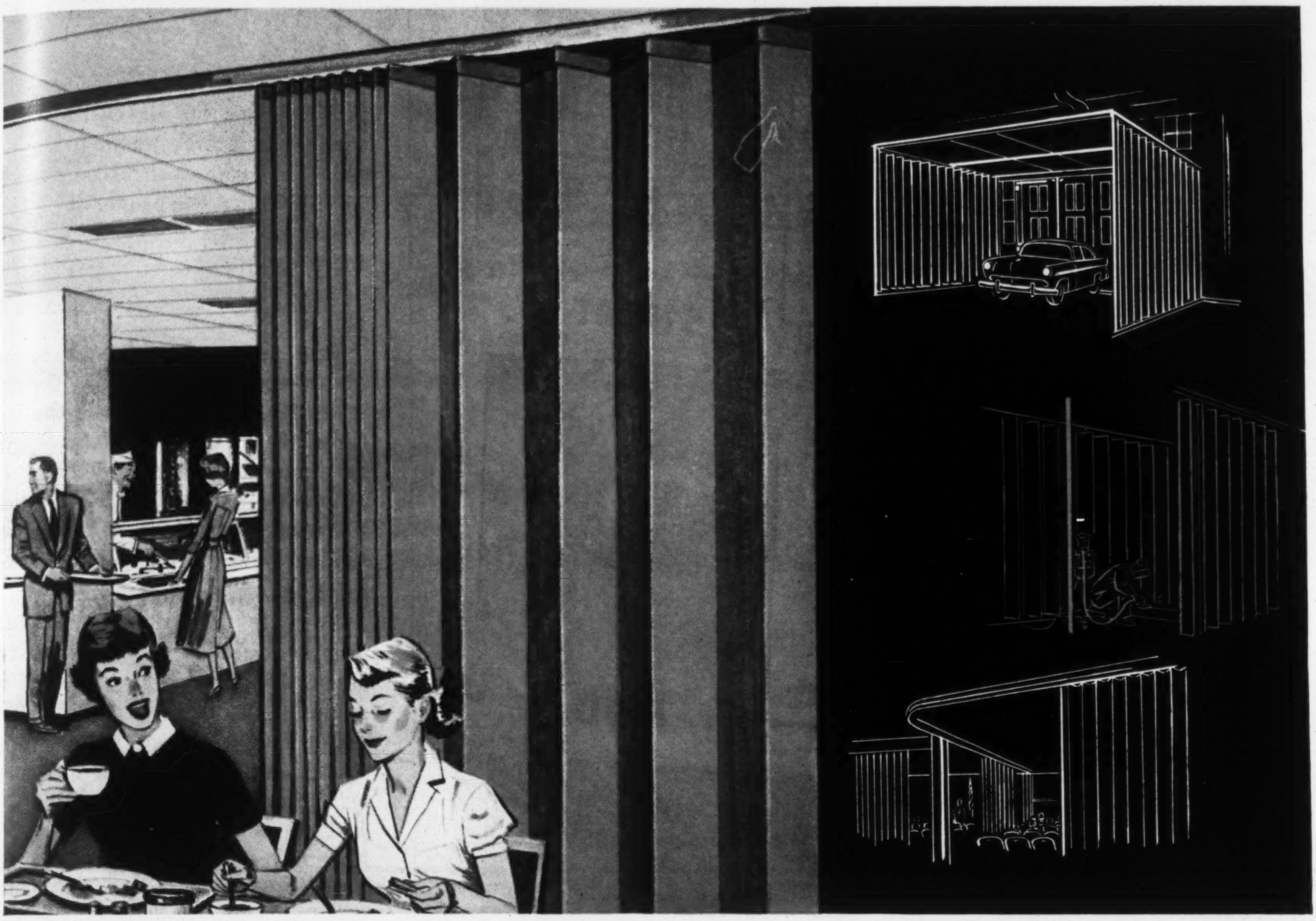
Mr. Garrett, referring to the Panel report, says that some aircraft castings are very intricate in design and need considerable development work before they can be produced at all. Designs of castings are fixed by the aircraft makers and patterns are made and submitted to the foundries. At this stage, the foundries hesitate to criticize the design of either the casting or the pattern. Many foundries think the aircraft people are not seriously interested in using castings and, in turn, the foundries are not particularly interested in accepting aircraft business.

Mr. Garrett believes that this impasse between aircraft people and foundries must be opened up before any notable progress in aircraft steel castings can be achieved. Once this barrier has been eliminated, he says, progress should be rapid.

Investment castings

Mr. Hodgson, in his paper "Design and Use of Investment Castings in Air Frames," says that definite progress has been made at Chance Vought in reducing aircraft costs by using steel castings. At present Chance Vought uses a great many magnesium and aluminum sand castings but various types of steel castings are also

Naugatuck MARVINOL



new folding wall with Marvinol VR-50

Transwall® Curtains* are opening the way to almost unlimited use of folding walls at lower costs than ever before. Why? Because the prime grade jute used is both impregnated and coated with Naugatuck's MARVINOL® VR-50. This versatile plastisol provides essential processing advantages necessary for economical production and additional product advantages necessary for profitable, high-volume sales.

VR-50, a high molecular weight PVC with exceptionally low plastisol viscosities, is specifically designed for dispersion applications. And while it enjoys a wide compounding latitude, VR-50 is a fast-processing, uniform resin with exceptional clarity in unfilled compounds. It is being successfully used for coating, spraying, film casting, slush molding, dipping, rotational molding, mold casting and foamed vinyls.

VR-50 is only *one of many* MARVINOL resins manufactured by Naugatuck for standard and "special" applications. And that's only part of the picture! Naugatuck also makes available complete technical and engineering services, too. So, no matter what your problem, or your product, it is to your advantage to get in touch with Naugatuck.

*Produced by TRANSWALL COATED PRODUCTS, a department of Bemis Bro. Bag Company, Minneapolis, Minnesota.

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Since the availability of Teflon, "John Crane" engineers have worked with Industry to successfully solve innumerable problems and develop new applications. *You can benefit from their experience and know-how.*

Thickness Inches	Nominal Size
1/16	12 x 12
3/32	18 x 18
1/8	24 x 24
3/16	36 x 36*
1/4	48 x 48*
3/8	
1/2 & Up	

* Can be furnished in 1/2 sheets

SHEET

DIAMETER INCHES

1/4	1
5/16	1 1/16
3/8	1 1/8
7/16	1 1/4
1/2	1 3/8
9/16	1 1/2
5/8	1 3/4
3/4	2
7/8	2 1/4
	2 1/2
	3

Other diameters on specification

ROD

TYPICAL SIZES INCHES

O. D.	I. D.
3/8	1/4
1/2	3/8
3/4	1/2
1	3/4
1 1/2	1
2 1/2	1 1/2
3	1 3/4

TUBING

Characteristics of Teflon

CHEMICAL
Completely inert.
ELECTRICAL
Very high dielectric strength.
Extremely low power factor.
THERMAL
Temperature range −300° to +500° F.
MECHANICAL
Strong, flexible, weather resistant.
LOW COEFFICIENT OF FRICTION
Absolutely non-stick.

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used, the largest weighing 285 lb. About 40% of all castings are made by the investment process—most of them steel. According to Mr. Hodgson, the proportion of investment castings used will be increased as soon as larger investment castings become available.

One serious problem cited by Mr. Hodgson which affects the use of castings in aircraft is the uncertainty of delivery dates; typical examples include delivery in 16 weeks instead of the promised 2 weeks and delivery in 44 weeks instead of the promised 15 weeks.

Cast steel properties

Steel is not competitive with other aircraft materials on a strength-weight basis unless it is available at a strength of 180,000 psi or higher. Since there is little sound engineering data available on the properties and behavior of cast steels at such strength levels, Mr. Ely and his associates at American Brake Shoe Co. made an investigation of the tensile and impact properties of several relatively low alloy martensitic steels, chiefly 4340. The investigators highly recommend a homogenizing treatment for maximum ductility of these high strength materials. A typical treatment: 1) a 4 hr homogenization treatment at 2280 F, 2) air cooling, 3) heating 6 hr at 1800 F, 4) air cooling, 5) heating 3 hr at 1600 F, and 6) air cooling. This treatment results in an 8.5% elongation value; normally 6% elongation is considered ample for most applications.

Reinforced Teflon Is Strong, Tough

Reinforced Teflon tapes, rods, tubes and slugs are now being marketed by Enflo Corp., Route 38 at Airport Circle, Pennsauken, N. J. Called Enflon, the reinforced material is said to be reasonably

GENERAL PLATE

Platinum Laboratory Ware

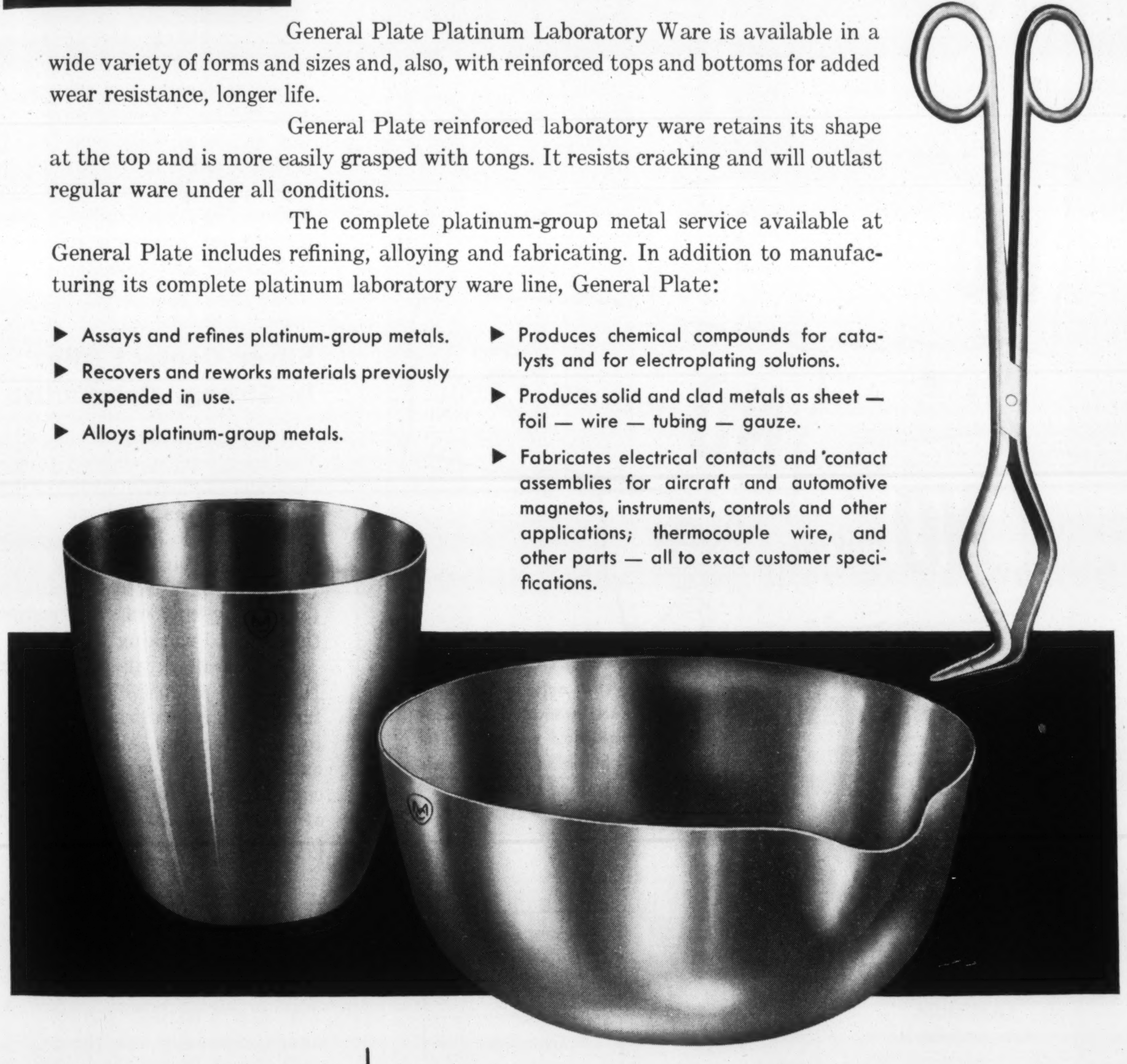
Available with reinforced tops and bottoms

General Plate Platinum Laboratory Ware is available in a wide variety of forms and sizes and, also, with reinforced tops and bottoms for added wear resistance, longer life.

General Plate reinforced laboratory ware retains its shape at the top and is more easily grasped with tongs. It resists cracking and will outlast regular ware under all conditions.

The complete platinum-group metal service available at General Plate includes refining, alloying and fabricating. In addition to manufacturing its complete platinum laboratory ware line, General Plate:

- ▶ Assays and refines platinum-group metals.
- ▶ Recovers and reworks materials previously expended in use.
- ▶ Alloys platinum-group metals.
- ▶ Produces chemical compounds for catalysts and for electroplating solutions.
- ▶ Produces solid and clad metals as sheet — foil — wire — tubing — gauze.
- ▶ Fabricates electrical contacts and contact assemblies for aircraft and automotive magnetos, instruments, controls and other applications; thermocouple wire, and other parts — all to exact customer specifications.



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ELECTRICAL PROPERTIES OF ENFLON

Dielectric Constant (1 mc)	2.269
Dissipation Factor (1 mc)	0.00064
Surface Resistivity, ohms	2×10^{13}
Volume Resistivity, ohm-cm	2.5×10^{13}
Dielectric Strength, v/mil	
30 mil	546
60 mil	410

stable at 575 F, and to surpass conventional Teflon in such properties as tensile and compressive strenth, load, temperature, friction and wear resistance. The reinforced Teflon is also said to have less cold flow than conventional Teflon. The material is recommended for use as bearings, inserts, seals and gaskets.

Silver Contact Alloy Is Strong, Conductive

A new silver alloy, developed by Venture Corp., is claimed to have electrical conductivity higher than 75% IACS as well as tensile strength and hardness greater than that of coin or sterling silver. It can be cast, rolled, drawn or formed by any of the conventional metal-working methods.

The new alloy, called Ventureloy II, is used extensively as an electrical contact material. It is said to be better than silver-cadmium oxide because it can take greater current loads, higher frequencies of operation and greater contact forces.

Plastisol Coating Protects Stored Parts

A new plastisol coating, designed especially for the protection of metal parts and products that are to be warehoused and exposed to rough handling, has been introduced by Auburn Button Works, Inc., Chemical Div., Auburn, N. Y.

The coating is applied to metal

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Vulcanized Fibre

TAYLOR FIBRE CO.
Plants in Norristown, Pa. and La Verne, Calif.

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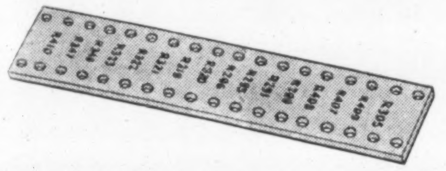
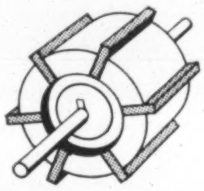
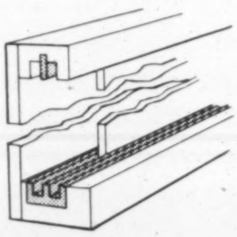
Tips for designers



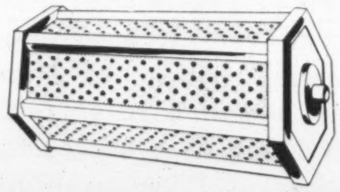
Terminal board for a complex circuit in an electronic spectrophotometer is made of Taylor Grade LE laminate . . . selected for its insulating and mechanical properties.



Gas pump impeller unit is fabricated of Taylor Grade LE-6 phenolic laminate . . . economical, light-weight, wear-resistant . . . chosen because of strength, stability.



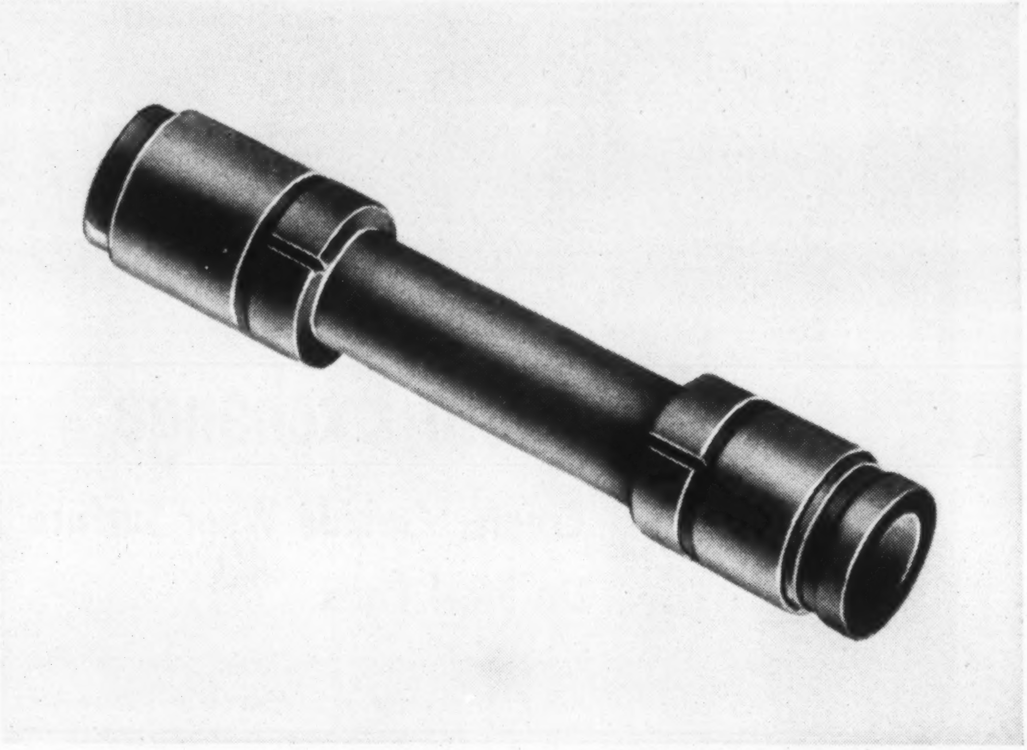
Guides for sliding doors, made from Taylor vulcanized fibre, last longer because of high strength and resistance to abrasion.



Metal plating barrels of Taylor Grade C-5 melamine withstand corrosion and erosion successfully in alkaline solutions. Downtime and maintenance costs are substantially reduced.

TAYLOR SUPERIOR COPPER-CLAD LAMINATES

Taylor GEC (glass epoxy) Copper-Clad and Taylor XXXP-242 cold punching (paper-phenolic) Copper-Clad. Taylor uses high purity rolled copper on base materials with outstanding electrical properties.



This coil form for radio frequency transformers is fabricated by Taylor of Grade XX laminate plastic tubing for Collins Radio Co. The O.D. of the center section is held to a tolerance of .230″ ± .0005″. Material was chosen for its good electrical properties, dimensional stability and machineability.

Precise electrical insulation parts? Taylor can produce them.

This coil form for radio frequency transformers was produced by Taylor's Fabricating Division, holding the tolerance of the outside diameter of the center section to ± .0005″.

Taylor has special techniques and facilities capable of providing parts—such as this coil form—to your own specifications, promptly and economically. You can shorten your production steps by putting Taylor to work for you . . . simplifying production . . . safeguarding schedules . . . reducing overall costs.

Precision fabrication of laminates and vulcanized fibre is difficult . . . but Taylor can and is doing it, in a great variety of Taylor grades, and to extremely close tolerances. In your present products or in those that are now on your drafting boards are opportunities for you to take advantage of Taylor's equipment and experience. Design to closer tolerances—Taylor can handle the job. Taylor is equipped to handle any type of fabrication—punching, drilling, grinding, forming, milling or turning—simple or complex.

Chances are that Taylor's staff of specialists can help you with design, material selection and fabrication. Call or write your nearest Taylor sales office for a talk about your needs.

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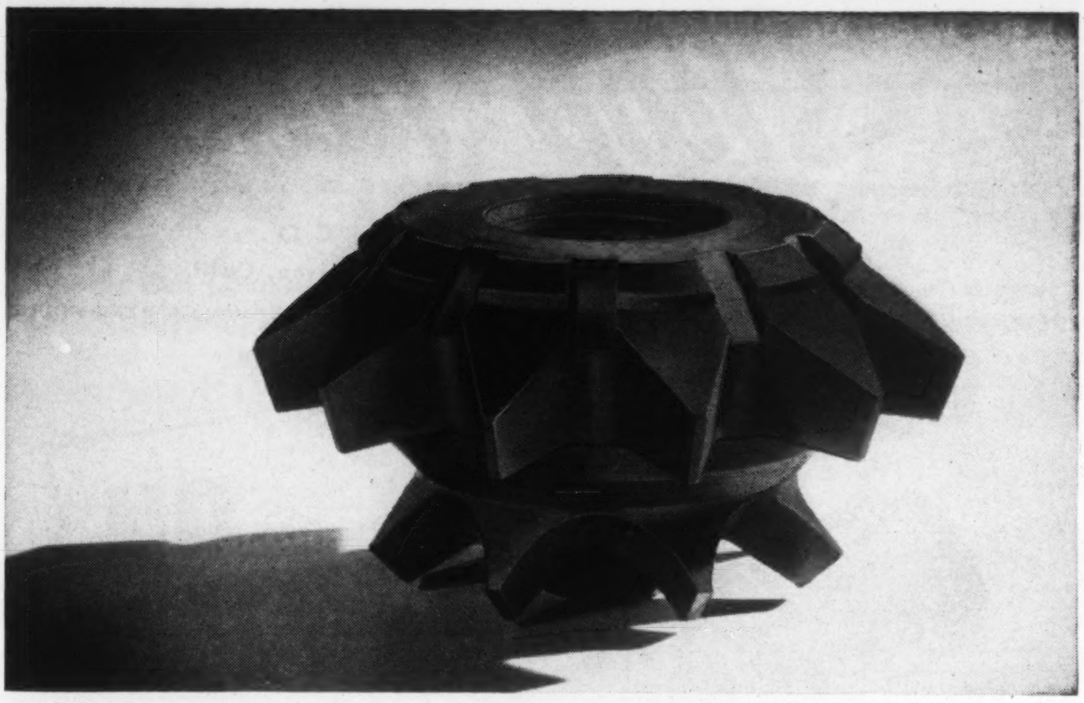
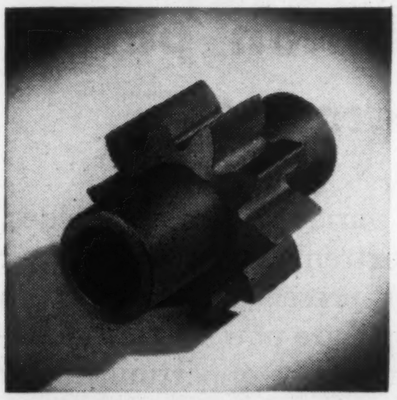

Oil well drill bit, carbide-surfaced by ASC, outlasts 5 untreated bits . . . cuts downtime 50% for oil exploration company.

The original stainless steel crimping roller showed definite signs of wear after processing 1 to 1½ million food cans. Identical rollers, ASC treated, processed 28 million food cans . . . showing no appreciable wear.


An ASC treated gear pump component outlasts 6 untreated units. In addition, its corrosion and heat resistance prevents contamination of the plastic material being processed.

Drive and spur gears, after ASC Metal Diffusion Treatment, have 3 to 4 times the wear resistance of untreated gears.

Atom Exchange

Creates Carbide Wear Surface On Steel Parts

Iron, steel and ferrous-base products which have to take the punishment of severe wear can now be given a treatment which vastly increases their resistance to wear and abrasion.

The new ASC Metal Diffusion Process produces a chromium-carbide surface on steel parts — medium and high carbon, regular, alloy or stainless.

The surface hardness, RC70-72, provides at least three times normal wear under the most difficult operating conditions . . . 10 to 30 times normal wear for many applications.

Even *stainless steel* can be vastly improved wearwise.

By *atom exchange* ASC Metal Diffusion Process produces a chromium surface which is an integral part of the parent metal. In addition to providing wear and abrasion resistance, this surface affords corrosion and heat resistance equal to 430 Stainless Steel.

Further information about this revolutionary process is yours for the asking. Write for additional data, consultation, or product demonstration.

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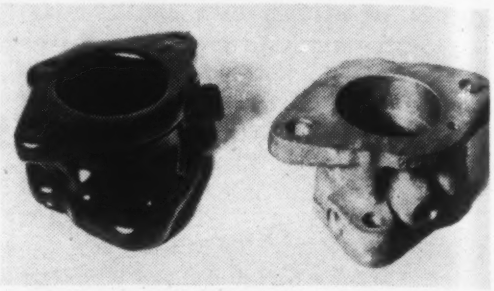

Cast iron part *is shown coated with plastisol formulation (left) and stripped of coating (right).*

parts by heating the part and dipping it into the plastisol formulation. The resulting thick plastisol cushion is said to resist mold, mildew, salt air and water, and most acids, alkalis and solvents. It is also said to have high thermal and electrical insulating qualities, and to be unaffected by extreme cold and hot weather.

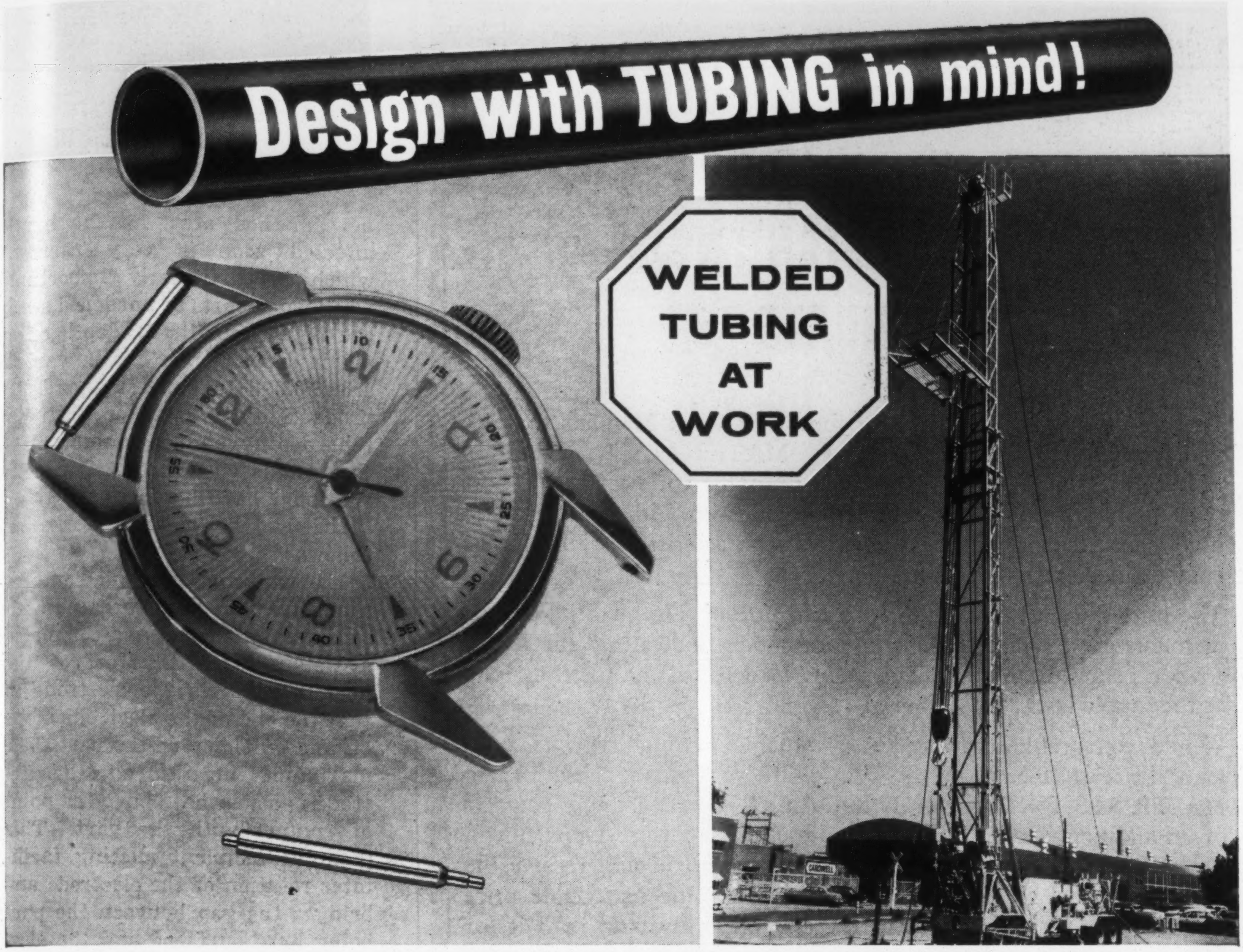
The plastisol coating, which may be peeled off by hand, is recommended for all types of sharp edged precision instruments and parts such as bits, sawblades, chisels, gear teeth and knives.

Hard Surfacing Method Developed in Russia

A low cost method of hard surfacing has recently been developed in Russia. Called the Vibrocontact method of hard surfacing, it is now being used successfully in a number of Russian automotive repair shops to repair worn parts of hardened steel.

An illustrated description of the method and a list of some of its advantages are given by Efremov and Gevorkyan in the Dec '56 issue of *Vestnik Mashinostroyeniya* (Russian). According to the authors, wear tests conducted on a chromium-nickel steel hard surfaced with a high carbon unalloyed steel electrode by the Vibrocontact method show 40 to 70% less wear when compared with the same steel in the carburized and hardened condition.

Other advantages listed for the



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Great structural strength, lightweight for mobility, uniformity for inter-working parts—all recommend Welded Carbon Steel Tubing for this oil country drilling rig.

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An Association of Quality Tube Producers

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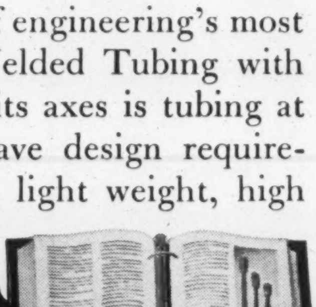

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The 260-page Handbook of Welded Steel Tubing contains inspiration and data for tubing designs. For your copy, write on your company letterhead, giving your title.

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....Magnesium and Its Alloys
....Conversion Coatings for Metals
....Synthetic Rubbers

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new method are: 1) the heat-affected zone is very narrow, which is particularly important when worn parts of hardened steel are being rebuilt, 2) depth of a single deposit layer can be varied from 0.005 to 0.080 in., and 3) productivity is greater than in rehardening and chromium plating and is equal to that in conventional hard surfacing.

Briefly, the method works as follows:

1. A rotating electrode contacts the metal to be hard surfaced with considerable impact and completes a welding circuit. Most of the heat develops in the electrode so that the end of the electrode melts off and builds up on the part. The maximum temperature in the electrode is somewhat above the point of contact with the part. This point of incipient melting facilitates rotation of the electrode and bridges the gap between the part being hard surfaced and the electrode.

2. The deposited metal is cooled rapidly with a coolant. Heat conduction by the cooler part also speeds up cooling of the deposited metal. The coolant also protects the weld metal from atmospheric oxygen and nitrogen.

3. The weld deposit is separated from the balance of the electrode by continued rotation of the electrode and drawback of the electrode from the part. Repetition of the cycle forms a weld deposit. With a high carbon unalloyed steel electrode, surface hardness of the weld deposit is 800 to 1000 Vickers.

Polyethylene Resin for Sheet Forming

A new polyethylene resin, for use in making heavy sheet for thermo-forming (i.e., sheet-forming), has been developed by E. I. du Pont de Nemours & Co., Wilmington 98, Del. The new ma-

For more information, circle No. 593 ➤

terial, designated Alathon 31, is said to give manufacturers a composition that has a high enough viscosity to resist sagging during the preliminary heating step of the thermo-forming process, yet is easily extruded into sheet and shaped into finished parts when drawn down over the thermo-forming mold.

The polyethylene resin has a melt index of 0.6 and a density of 0.93. Parts made of the resin have glossy surfaces, are resistant to environmental stress cracking, are essentially free of taste and odor, and are said to be completely nontoxic.

The material is suited for use in thermo-forming containers for foods such as ice cream and cottage cheese, and for fabricating trays, covers, liners, lids, shoe components, hats and other items formed from sheet material. The resin is currently available at 41c per lb in minimum truck loads.

Zinc-Rich Paints Resist Toxic Fumes

Carboline Co., 331 Thornton Ave., St. Louis 19, has announced the development of a series of zinc-rich paints for atmospheric, marine and chemical plant protection.

The cured paints are said to offer a tight, nonporous, 4 to 10-mil film in one coat. According to the producer, a new coat can be applied in the field to continue the protection when the zinc is eventually spent.

Three types of coatings are available: XR 150-40 for lining fresh water tanks and pipe; XR 150-62 for lining brine tanks and protecting sandblasted steel from marine and industrial atmospheres; and XR 150-43 for application to rusty, wirebrushed structural steel in industrial and marine atmospheres.

More What's New on p. 188

PURITY plays a part in SANDVIK Spring Steel's Super-Performance

Basic purity has a lot to do with Sandvik's ability to deliver top performance in so many difficult spring steel applications. This purity begins with the purest iron ore—obtained from Sandvik's own mines.

Step by step in the production of the quality strip steel, close control is held on the product. Only the purest materials, such as sulphur-free charcoal and sponge iron are used in the furnaces. The only return scrap used is from the Sandvik plant itself.

Sandvik supplies cold rolled specialty strip steels —

- **In special analyses for specific applications**
- **Precision-rolled thicknesses to fit your requirements**
- **In straight carbon and alloy grades**
- **Annealed, unannealed or hardened and tempered — scaleless or polished bright, yellow or blue**
- **With square, round or dressed edges**

Sandvik stocks a wide variety of qualities and sizes. In addition Sandvik has Rolling, Slitting, Edge-Filing and Hardening and Tempering facilities.

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Sandvik Quality Steels

For more information, turn to Reader Service card, circle No. 473

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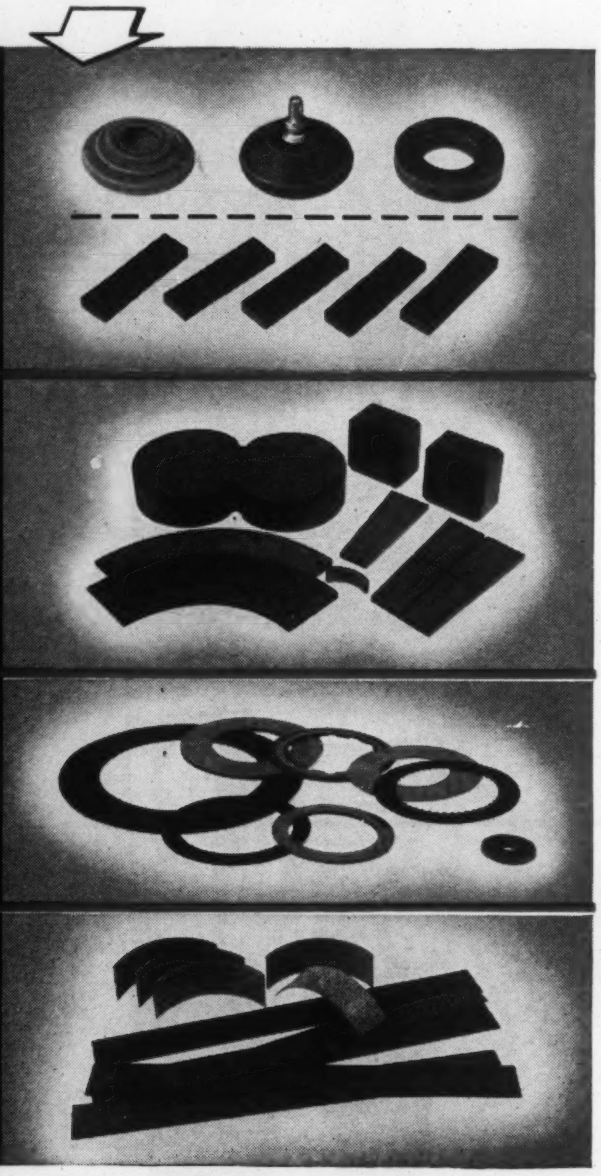

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For more information, turn to Reader Service card, circle No. 365

What's new IN MATERIALS

New Silicone Rubber for Wire Insulation

A new silicone rubber compound designed especially for wire insulation is capable of withstanding intermittent exposure to temperatures as high as 480 F. Designated SE-975 and available from General Electric Co., Silicone Products Dept., Waterford, N. Y., the compound is recommended for use on aircraft wire, motor and apparatus lead wire, defroster and hook-up wire, and other wires.

Said to have good electrical and physical properties and low water absorption, the silicone wire insulation may be used in long service at 300 F and for many applications at 390 F. After a cure of 1 hr at 300 F, tensile strength is 1150 psi, elongation is 425% and tear strength is 125 lb per in.

According to the producer, SE-975 has good processing characteristics that make it especially suited for thin wall extrusions. The silicone rubber is furnished as a white compound and may be tinted to obtain various colors.

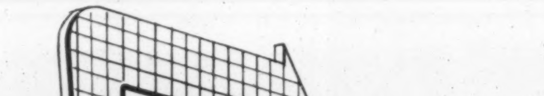
Glass-Epoxy Laminate Is Flame Retardant

A new flame retardant glass-epoxy laminate has been introduced by Continental Diamond Fibre Corp., Newark, Del. According to the producer, the glass-epoxy laminate shows excellent flame resistance when tested in accordance with NEMA switchgear flame resistant requirements. Said to have high strength and good electrical properties, the insulating laminate is heat resistant and can be used continuously at temperatures up to 300 F.

The laminate is recommended for such applications as circuit breaker arms, flash guards and insulating barriers; panels, subpanels, terminal boards and other

A sign that's NEW every day

Changeable letters of Tenite Butyrate keep sales messages fresh and timely



TENITE BUTYRATE
an Eastman plastic

Changeable letter displays, once found exclusively on theater marquees, have now been adopted by the nation's retailers. They have found that sales, daily specials, current attractions, extra services—a wealth of up-to-the-minute information—can be conveyed to prospective customers through the adaptability of plastic letters.

Tenite Butyrate is playing an important role in the success story of these signs. The brilliant luster, wide color range and outdoor durability of this Eastman plastic have made it the preferred material for effective, eye-catching letters. In Tenite Butyrate, leading sign manufacturers have found a plastic that spells long life for the letters they sell...a material whose toughness cannot be matched by any other weather-durable plastic.

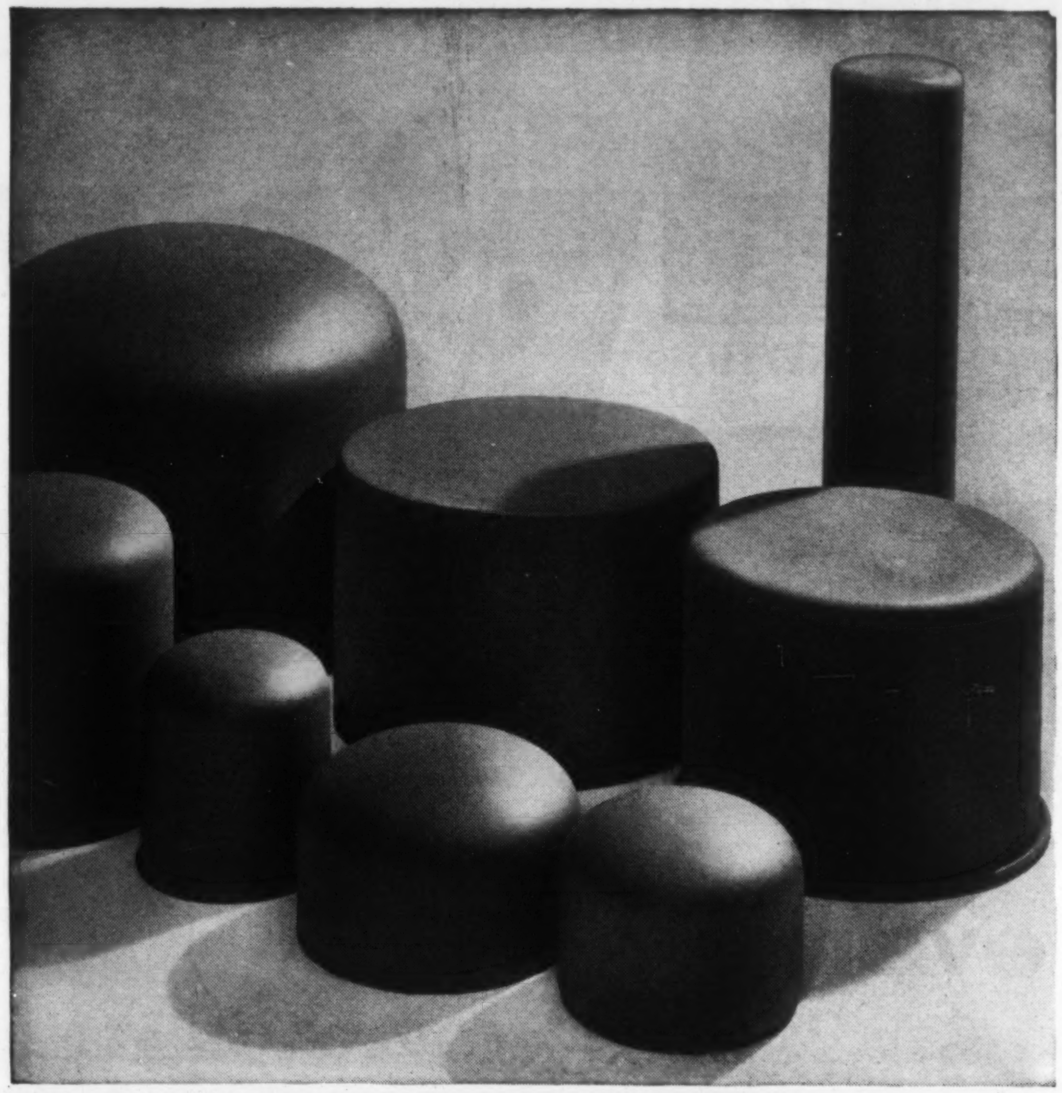
Letters are but one of many applications for Tenite Butyrate in the sign industry. This thermoplastic material can be easily molded, or extruded as sheet and then formed by vacuum, air or mechanical pressure. Because of its high strength, economical lighter gauges often can be used in sign construction.

An ideal material because of its durability, dimensional stability, toughness and workability, Tenite Butyrate is used in outdoor sign applications ranging from letters like those shown above to huge spectaculars 40 feet high. For more information on any use you may have for this strong, versatile plastic, write **EASTMAN CHEMICAL PRODUCTS, INC.**, subsidiary of Eastman Kodak Company, **KINGSPORT, TENNESSEE.**

1932—EASTMAN'S 25TH YEAR IN PLASTICS—1957

Information regarding Tenite also can be obtained from local representatives listed under "Plastics—Tenite" in the classified telephone directories of the following cities: Atlanta, Chicago, Cleveland, Dayton, Detroit, Houston, Kansas City, Leominster (Mass.), Los Angeles, New York City, Portland (Ore.), Rochester (N. Y.), St. Louis, San Francisco, Seattle and Toronto—elsewhere throughout the world, from Eastman Kodak Company affiliates and distributors.

For more information, turn to Reader Service card, circle No. 450



Keep pace with the march of design with Hackney deep drawn shells

Your customers want smartly designed products...good looking and durable. Your production engineers demand parts that are readily obtainable...easily and quickly assembled...made to accurate specifications. Management says reduce weight and cut unit costs.

Many product designers have found a single way to solve all these problems. They specify Hackney deep drawn shapes or shells. These lightweight, seamless parts may be cylindrical, spherical, conical or tapered...most any streamlined shape your designs call for. Capacities from one quart to 70 gallons. Flanges, openings, fittings or brackets placed where you need them. Just send us a sketch of what you have in mind. Let us know whether you're thinking of steel, stainless steel, nickel, aluminum, magnesium, copper or alloy. We'll send you the details.

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CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

For more information, turn to Reader Service card, circle No. 515

related power equipment; and radio and television relays, printed circuit panels, and other electronic parts.

The laminate is supplied plain for power applications and in metal-clad form for printed circuitry. It is available in sheets ranging from 0.010 to 1 in. in thickness.

Standard Issued on Rigid PVC Sheet

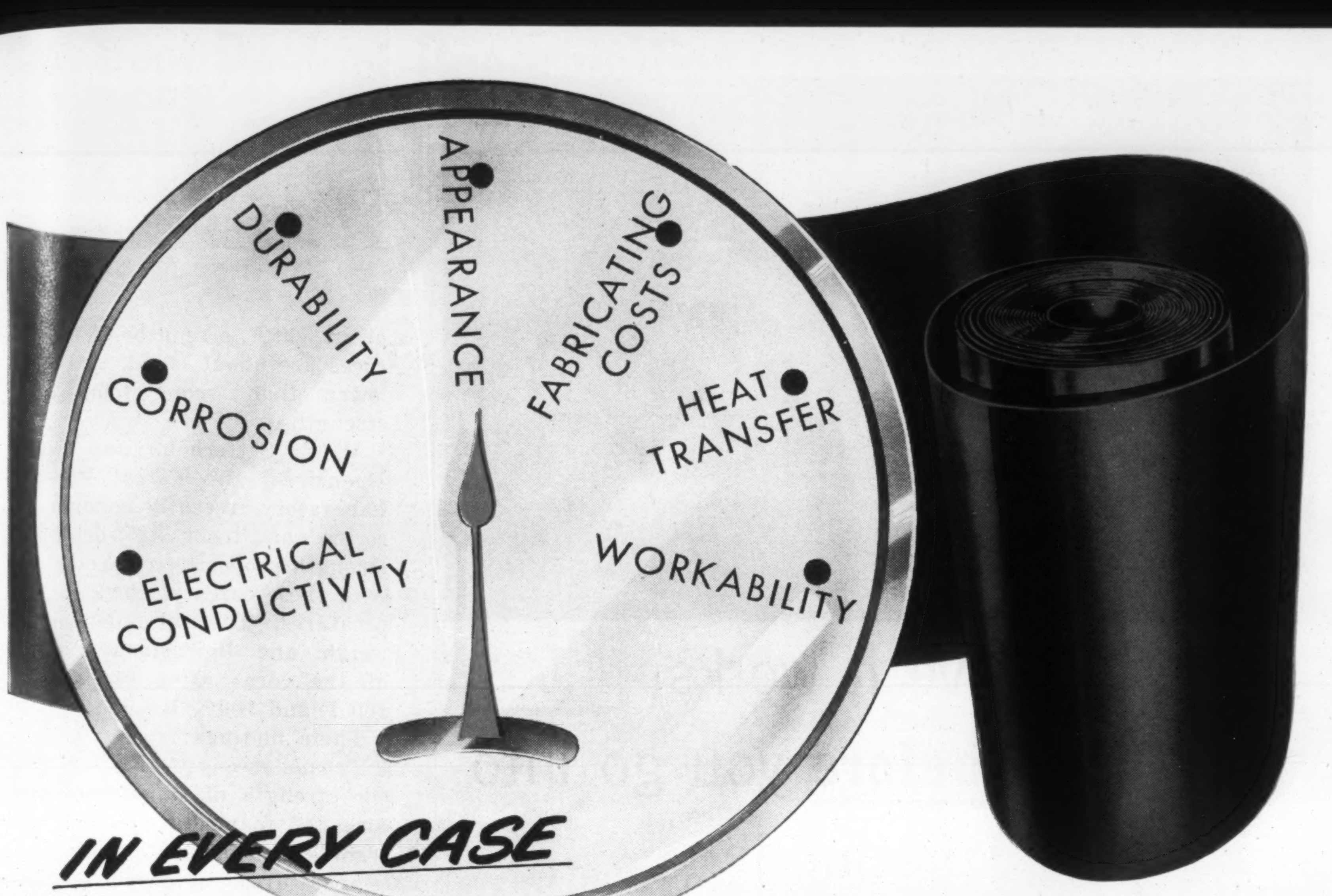
A commercial standard for rigid polyvinyl chloride plastics sheets has been issued by the Commodity Standards Div., of the U.S. Dept. of Commerce in cooperation with the Society of the Plastics Industry, Inc. The standard, known as Commercial Standard CS201-55, covers physical and chemical properties and methods of test for normal impact (Type I) and high impact (Type II) rigid PVC sheets.

The standard contains information on two identification marks for the use of manufacturers in identifying products conforming to the standard. A recommended method of declaring compliance with the standard has been incorporated.

How Foams Perform at High Temperatures

Urethane foam sandwich cores are much stronger than silicone foam cores of the same density at temperatures below 300 F, recent tests show.

At 75 F, tension, compression and shear strength values for the urethane foam cores are several times as great as those for silicone cores of the same density. As temperatures increase above 75 F, however, the urethane foam cores decrease in strength at a greater rate than silicone cores. When temperature is increased to



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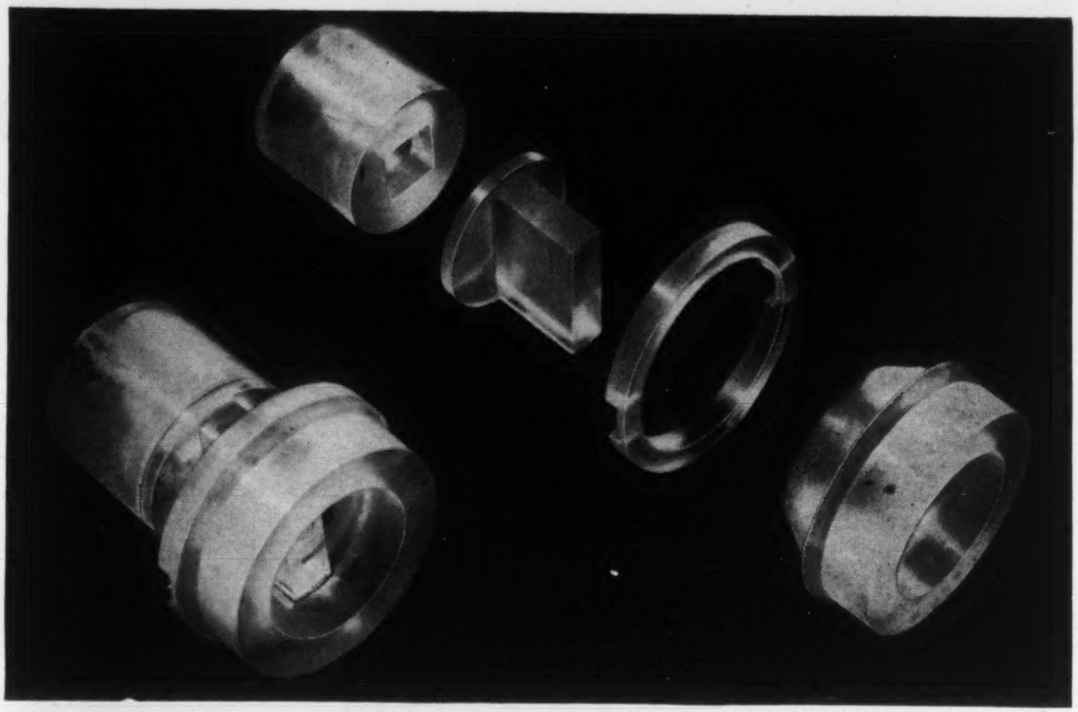

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before you go into production

Machine that part from polystyrene and let us investment-cast it in the metal you plan to use. Test it and, if some change is indicated, repeat the process until you have the final answer. This cut-and-try method of proving a design and an alloy saves you a lot of time and money.

Polystyrene machines readily and is inexpensive. Complex patterns can be made in sections and assembled, then cast as a unit just as they'd be investment-cast in quantity. Thus parts for testing are exactly like you'll get in production, but they cost far less than cutting them out of metal.

Technical Data Available

When your idea is on paper, but before you start to make the polystyrene patterns, send us a blueprint. We'll figure the shrinkage factor for you, suggest possible gating arrangements and design modifications which may effect further economies.

The pamphlet, *A Guide for Making Polystyrene Patterns*, describes methods of machining and names sources from which this material can be obtained. For a free copy, write Precision Metalsmiths, Inc., 1077 East 200th Street, Cleveland 17, Ohio.

pour yourself an assembly with

PRECISION METALSMITHS INC.

INVESTMENT CASTINGS

For more information, turn to Reader Service card, circle No. 474

about 500 F, strengths of the two cores are about equal, and much lower than room temperature strengths.

V. C. Setterholm and E. W. Kuenzi, of the Forest Products Laboratory, recently conducted a series of tests to determine strength properties of sandwiches with these cores at elevated temperatures. They also determined weight and dimensional stability of the cores after exposure to 100 F and 100% RH.

Their findings:

Tensile strength—Flatwise tensile strength of sandwiches with cores of foamed-in-place silicone resin decreases with increasing temperatures. Average strength values decrease from a high of 19 psi at room temperature to a low of 0 psi at 700 F. The scattering of strength values at all temperatures below 700 F indicates a considerable amount of nonuniformity within the foam. Although the silicone foam adheres tightly to the facings, examination of failed specimens shows that the weakest point in the foam appears to be at a point immediately adjacent to the bond between core and facing.

In urethane foam cores, tensile strength decreases very rapidly with increasing temperature, the most rapid losses occurring at temperatures between 300 and 400 F. Average tensile strength values for sandwiches with cores of urethane foam having a density of 11.9 to 12.2 lb per cu ft are 96 psi at 300 F and 5 psi at 500 F.

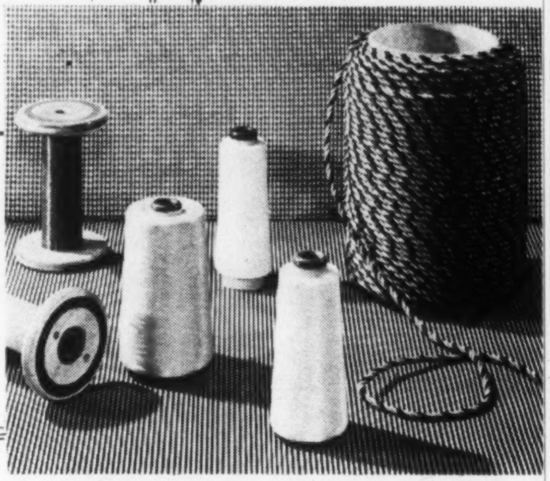
Compressive strength—Flatwise compressive strength of sandwiches with cores of foamed silicone resin also decreases with increasing temperature. At 75 F, sandwiches with a core in the density range of 17.3 to 17.5 lb per cu ft are about twice as strong as those with cores in a density range of 12.6 to 13.3. Heating specimens at 300 F for 192 hr has little effect on the compressive strength of cores in the density

For more information, circle No. 474 ➤

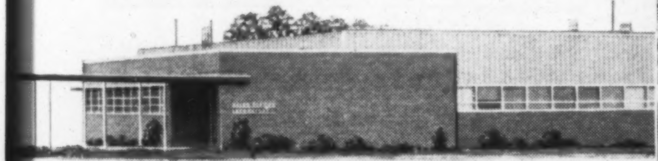
New Product Opportunities with Tough

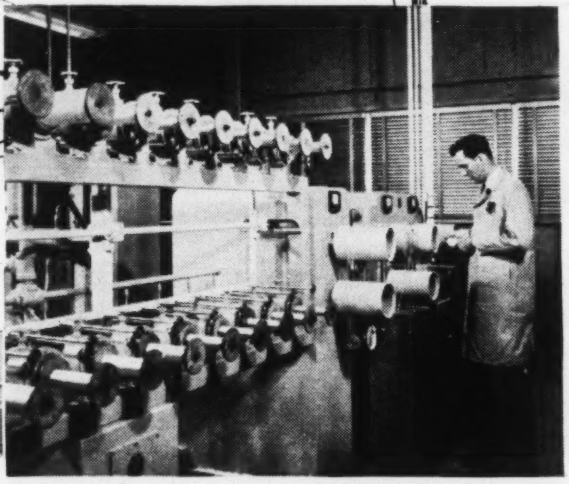
MARLEX* 50

POLYETHYLENE



MARLEX 50 monofilaments are easily extruded. They combine exceptional strength with low elongation. You can color them as brilliantly as a peacock's plumage, yet they will not stain. Never before have you had a fiber available which could do so much at such low cost. And talk about durability! MARLEX 50 fabrics can face the rigors of life in home and commercial laundries. Dry cleaning holds no terrors either, for MARLEX 50 textiles come up smiling every time.





Our new Sales Service Laboratory in Bartlesville, Oklahoma has one aim in life: to help you make the most of versatile MARLEX 50 polyethylene. Whatever your potential application, our staff is at your service. For more information, ask our Plastics Sales Representative who calls on you. Or get in touch with our nearest District Office listed below.

Filaments are extrusion-drawn under carefully controlled conditions at our Sales Service Laboratory. Here we can show you how to "tailor make" MARLEX 50 filaments for dimensional stability at elevated temperatures and with desirable stress-strain properties. Yarns and fabrics can be manufactured from this new plastic with conventional equipment and techniques.

Shoe uppers, indoor and outdoor upholstery, shower curtains, draperies, sailcloth, fishnets, tarpaulins, filter cloths, and rubber reinforcement are but a few of the attractive textile uses for this unique new filament of MARLEX 50 polyethylene. In cordage, MARLEX 50 is adapted for many applications, from a surgeon's suture to hawsers on the towing bitts of a tug.

*MARLEX is a trademark for Phillips family of olefin polymers.

PLASTICS SALES DIVISION, PHILLIPS CHEMICAL COMPANY

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Chem-o-sol is our trade name for specially formulated polyvinyl dispersions (plastisols), which free the designer from the limitations of conventional materials. Inherently versatile because of their "liquid solid" nature, these dispersions offer unlimited opportunity to solve old problems and to develop new products, new forms, new characteristics. They are simple to apply, whether adapted as coatings and finishes or as shaped components.

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See opposite page for technical data

For more information, turn to Reader Service card, circle No. 394

chem-o-sol® unlimited

TECHNICAL DATA

Chem-o-sol is supplied as a liquid and when fused at temperatures in the vicinity of 350°F. (some lower fusing compounds are available) results in a tough, resilient solid with all the outstanding physical and chemical properties associated with the polyvinyl chloride resins on which Chem-o-sol is based. Listed below are some of the properties which are available in Chem-o-sol in almost any combination:

COLOR
Available in any desired color.

TENSILE STRENGTH
As required within the range 1,000 psi. to 2700 psi.*

PERCENT ELONGATION
350 to 600*

HARDNESS (Shore A_2)
As required within the range 10 to 100.

FLEXIBILITY
A fused section of Chem-o-sol is flexible at temperatures as low as —65°F.

CHEMICAL RESISTANCE
Highly resistant to most acids, alkalies, detergents, and to a wide range of oils and solvents.

HEAT RESISTANCE
Equivalent to other versions of vinyl based compounds. Chem-o-sol, with resistance to temperature of 225°F. for as long as 2000 hours and to temperature of 450°F. for over two hours is available.

DIELECTRIC STRENGTH
Minimum of 400 volts per mil when fused in sections 3 mils thick and over.

SOLIDS CONTENT
100% — Chem-o-sol can be molded in very thick sections. Reproduction of mold surface is excellent.

APPLICABILITY
Chem-o-sol is readily applied by dipping, die wiping, molding, casting, spraying, or spreader coating.

VISCOSITY
As required for application method.

**As measured by Model IP-4 Scott Tester.*

Send For Chem-o-sol Brochure
When writing to us, use Page 10 of your chem-o-sol brochure as a guide to outline your project or new end use for Chem-o-sol. As soon as we know your requirements, our entire resources will be put to work.

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For more information, circle No. 394

ranges of 12.6, 13.3, 15.2 and 15.9 lb per cu ft, but the strength of cores with a density of 17.3 to 17.5 is 38% less than their strength after heating for only 15 min at 300 F.

Flatwise compressive strength of urethane foam cores also decreases with increasing temperature. Urethane foam cores heated at 300 F for 192 hr have greater compressive strength and greater stress at proportional limit than cores heated for only 15 min at this temperature. Compressive strength of the sandwich core increases 4%, and compressive strength of the core material increases 45%.

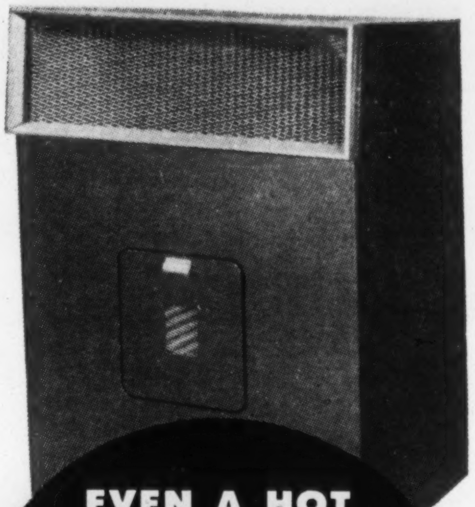
Shear strength—The average shear strength of silicone foam cores varies from a high of 12 to 16 psi at room temperature to a low of 4 to 6 psi at 700 F. The highest shear strength values of silicone foam cores tested at 700 F were found with specimens having a density of 15.2 to 15.9 lb per cu ft.

Heating urethane foam cores for 15 min at 300 F causes a slight reduction in average shear strength and shear modulus at 75 F; above 300 F the shear strength and modulus decrease rapidly. Heating specimens for an additional 192 hr at 300 F has no adverse effect on the shear strength of the core.

Urethane cores with average densities of 9.7 and 18.6 ft and silicone cores with a density of 12.4 were exposed to high humidity for 21 days at 100 F. The weight and size of the silicone cores were not affected by exposure to high humidity, but the urethane cores increased in both weight and dimension.

Rubber-Base Adhesive Joins Canvas, Ribbons

A water resistant, rubber-base adhesive developed especially for



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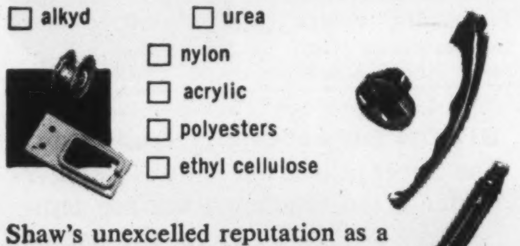

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"SHAW takes the problems out of plastic molding."

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custom molds all plastics
by TRANSFER • COMPRESSION • INJECTION

For more information, circle No. 375

joining fabrics and porous materials has been introduced by Raybestos-Manhattan, Inc., 1020 Simpson St., Bridgeport 2, Conn. Designated Ray-Bond R-87001, the adhesive is said to instantly join the ends of ribbons, elastic bands and other fabrics without slowing production.

The adhesive, applied by extrusion or brush, has a tensile strength (canvas to canvas) of 104 psi after 10 min and 112 psi after 24-hr aging. According to the producer, the adhesive should set for 24 hr to develop highest tensile strength, but joined parts may be used immediately after pressing together. The adhesive is not recommended for use where heat or solvents are present.

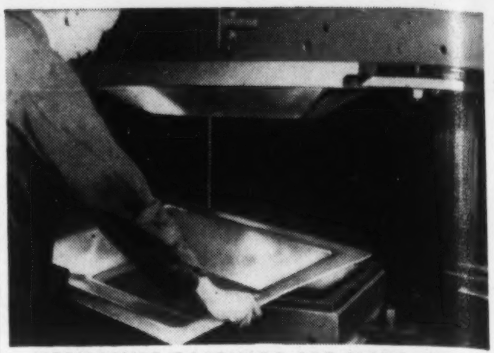
Fast Metallizing

National Research Corp., 70 Memorial Drive, Cambridge 42, Mass., announced recently the development of a high speed vacuum metallizing process that is said to produce highly reflective metallic coatings on plastics film, textile fabrics and, ultimately, paper. The process is said to make possible a virtually flawless metallized surface on plastics film used for metallic yarn, automobile interior trim, luggage, shoes and other applications. The developer claims the process is easy to control and that rolls of plastics film up to 60 in. in width can be metallized at speeds as high as 400 fpm.

Phenolic Compounds for Use in Appliances

Appliance parts molded from two new phenolic compounds recently developed by General Electric Co., Chemical Materials Dept., 1 Plastics Ave., Pittsfield, Mass., are said to withstand boiling water and oven-hot temperatures.

One compound, designated GE



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Centrifugally Cast Products Div., The
Shenango Furnace Co., Dover, Ohio
Compton Foundry, Compton, Calif.
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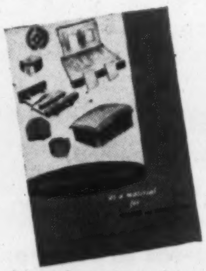
General Foundry & Mfg. Co., Flint, Mich.
Georgia Iron Works, Augusta, Ga.
Greenlee Foundry Co.. Chicago, Ill.
The Hamilton Foundry & Machine Co.,
Hamilton, Ohio
Hardinge Company, Inc., New York, N. Y.
Hardinge Manufacturing Co., York, Pa.
Johnstone Foundries, Inc., Grove City, Pa.
Kanawha Manufacturing Co.,
Charleston, W. Va.
Koehring Co., Milwaukee, Wis.
Lincoln Foundry Corp., Los Angeles, Calif.
Nordberg Manufacturing Co., Milwaukee,
Wis. and St. Louis, Mo.
Palmyra Foundry Co., Inc., Palmyra, N. J.
The Henry Perkins Co., Bridgewater, Mass.
Pohlman Foundry Co., Inc., Buffalo, N. Y.
The Prescott Co., Menominee, Michigan
Rosedale Foundry & Machine Co.,
Pittsburgh, Pa.
Ross-Meehan Foundries, Chattanooga, Tenn.
Sonith Industries, Inc., Indianapolis, Ind.
Standard Foundry Co., Worcester, Mass.
The Stearns-Roger Mfg. Co., Denver, Colo.
Valley Iron Works, Inc., St. Paul, Minn.
Vulcan Foundry Co., Oakland, Calif.
Washington Iron Works, Seattle, Wash.
Dorr-Oliver-Long, Ltd., Orillia, Ontario
Hartley Foundry Div., London Concrete
Machinery Co., Ltd., Brantford, Ontario
Otis Elevator Co., Ltd., Hamilton, Ontario



SEND FOR FREE BULLETIN 41 TODAY

Meehanite Metal as a Material for Forming & Stamping dies

Write today to Meehanite Metal Corporation, Department 1A, 714 North Avenue, New Rochelle, New York.

MEEHANITE®

For more information, circle No. 472 ➤

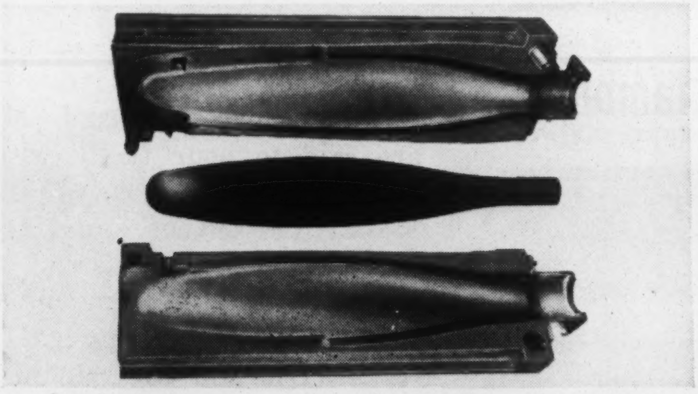
Increase die life and lower production costs with cast-to-form Meehanite metal dies

Longer service life is obtained with Meehanite dies because of their better wear resistance and freedom from galling, scuffing and scoring. Meehanite metal, combining the most desirable properties of gray iron and steel, is one of the most versatile die materials available.

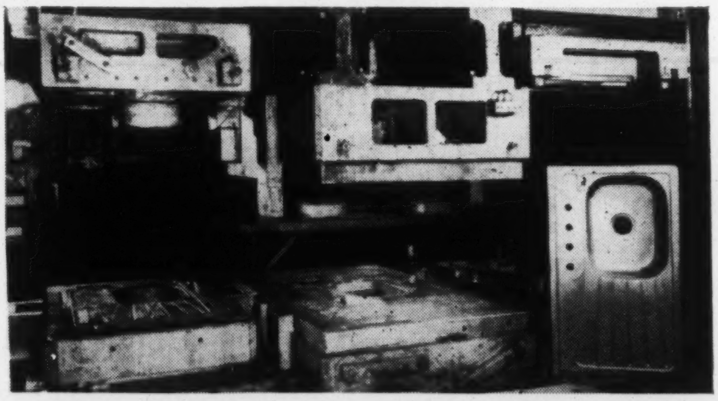
Meehanite dies provide high strength and toughness combined with excellent self-lubricating properties. Dies made in Meehanite metal take on a permanent glass-smooth finish and assure long runs of flawless pressings and shapes. Meehanite dies are used successfully for deep drawing and shaping all steels and non-ferrous alloys.

Substantially lower production costs are achieved by casting large and complicated die parts in one piece rather than building up die assemblies. Machining allowances are held to a minimum and dies may be hardened by local or uniform heat treating without distortion.

For additional information, send for Bulletin No. 41 "Meehanite Metal as a Material for Forming & Stamping Dies."



Steel airplane propeller blades that must be as near perfect as possible are manufactured with Meehanite dies that prevent distortion during quenching after heat treating. The dies shown contain cored passages through which cooling water flows.

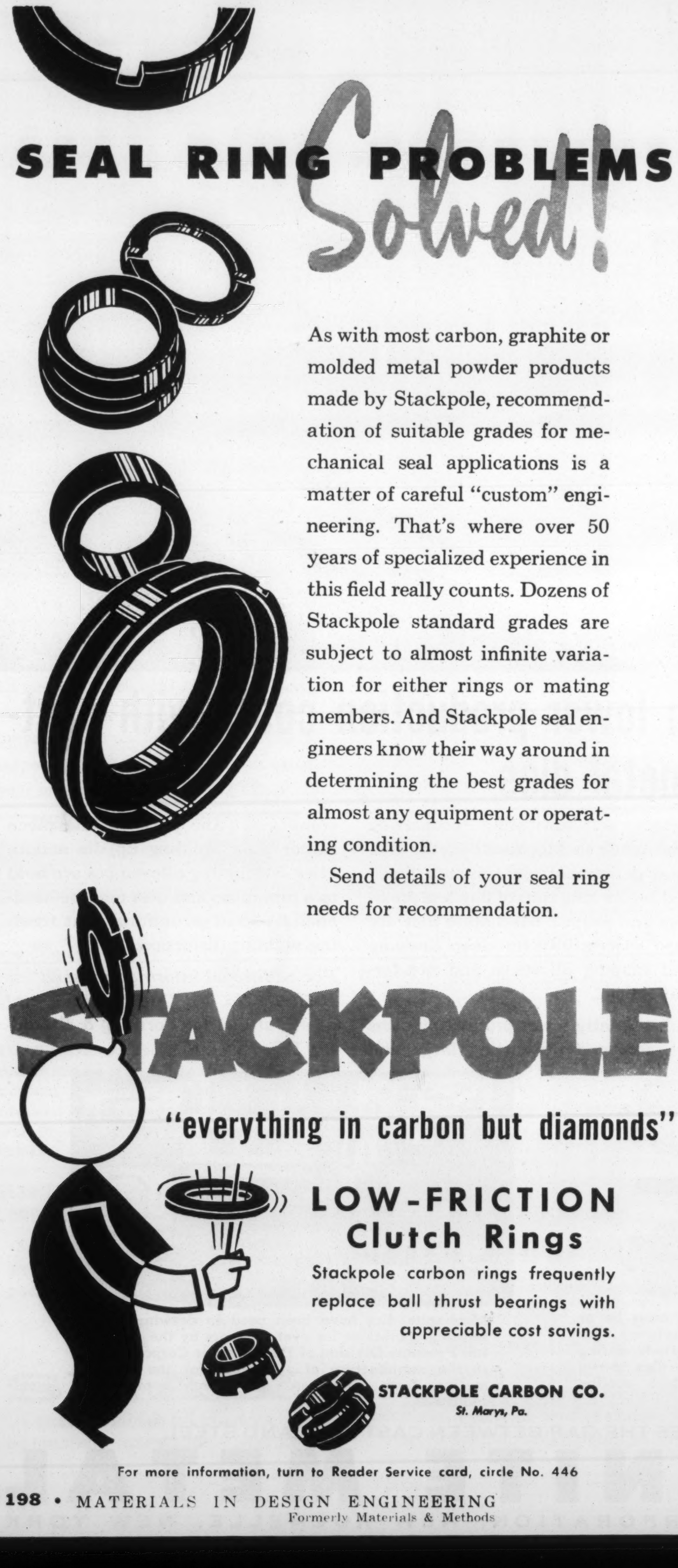


Meehanite dies have been used in drawing and forming operations for over 25 years by the Ingersoll Products Division of Borg-Warner Corporation in the manufacture of stampings for the automotive, farm equipment and home appliance industries.

MEEHANITE BRIDGES THE GAP BETWEEN CAST IRON AND STEEL®

MEEHANITE METAL

MEEHANITE METAL CORPORATION, NEW ROCHELLE, NEW YORK



SEAL RING PROBLEMS Solved!

As with most carbon, graphite or molded metal powder products made by Stackpole, recommendation of suitable grades for mechanical seal applications is a matter of careful "custom" engineering. That's where over 50 years of specialized experience in this field really counts. Dozens of Stackpole standard grades are subject to almost infinite variation for either rings or mating members. And Stackpole seal engineers know their way around in determining the best grades for almost any equipment or operating condition.

Send details of your seal ring needs for recommendation.

STACKPOLE

"everything in carbon but diamonds"

LOW-FRICTION Clutch Rings

Stackpole carbon rings frequently replace ball thrust bearings with appreciable cost savings.

STACKPOLE CARBON CO.
St. Marys, Pa.

For more information, turn to Reader Service card, circle No. 446

PROPERTIES OF GE 12980

Impact Strength (notched Izod), ft lb/in.	0.34
Flexural Strength, psi	8500
Modulus in Flexure, psi	1.2×10^6
Tensile Strength, psi	5500
Compressive Strength, psi	35,000
Water Absorption (24 hr) %	0.2
Rockwell Hardness	M119
Heat Distortion Temperature, F	380
Dielectric Strength (60 cycles)	
75 F	130
210 F	50

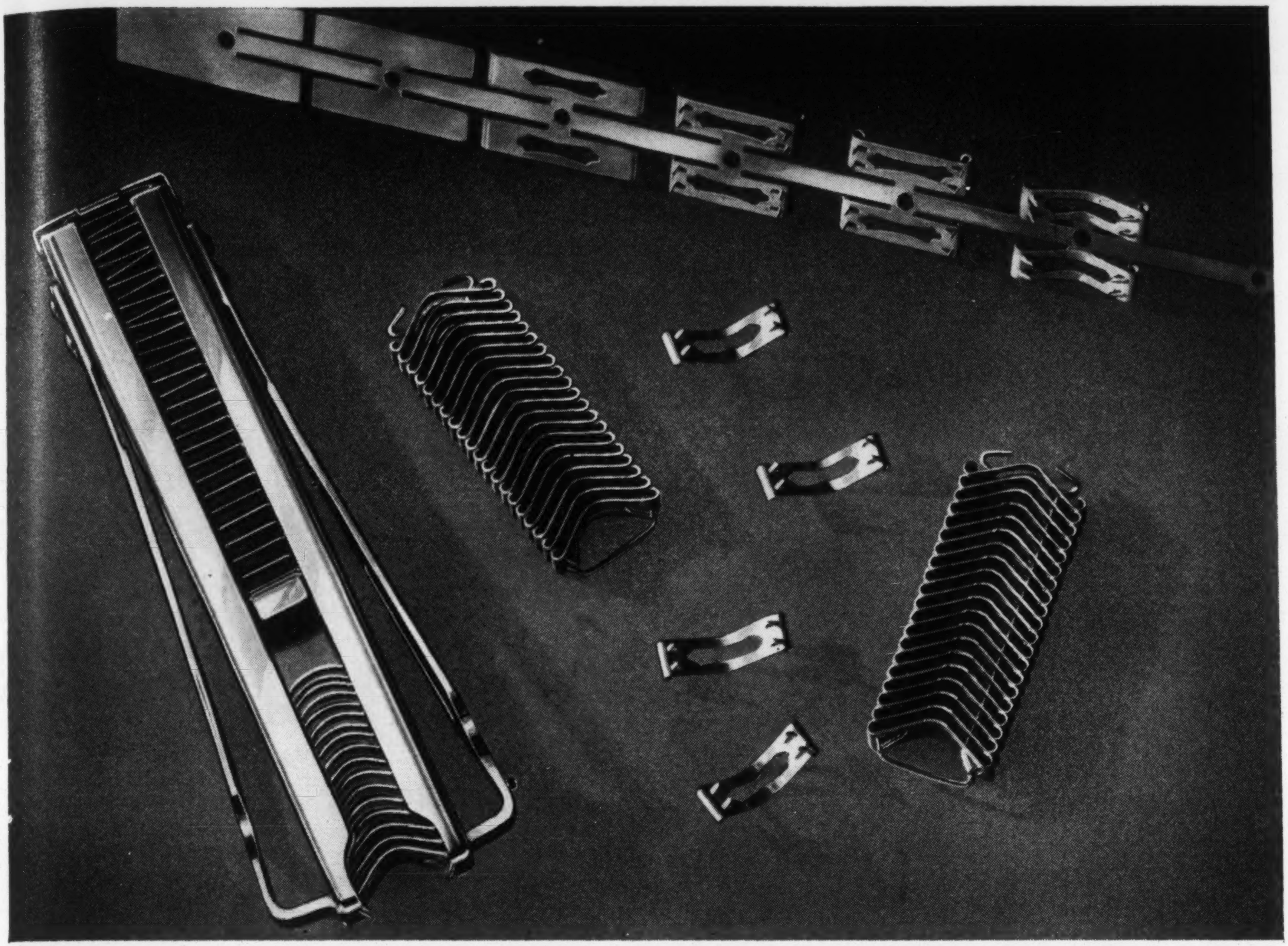
12980, is suitable for use in either cold powder or preheated pill molding and can be molded at temperatures ranging from 300 to 370 F using standard molding pressures. According to the producer, GE 12980 produces satin finished parts that can withstand temperatures up to 500 F. This compound is recommended for use in skillet handles, coffee pot bases and other applications where temperature requirements are critical.

A second compound, GE 12981, is a medium heat resistant material that is designed to resist temperatures up to 400 F. This material is suggested for industrial applications such as circuit breakers, cord connectors and thermostat knobs where strength and easy moldability are required.

Two Insulating Resins Pour Without Solvents

Two new silicone insulating resins, now available from Dow Corning Corp., Midland, Mich., are said to pour freely without solvents. Identified as R-7501 and R-7521, the solventless resins are 100% silicone materials that, upon curing, are said to form void-free, high temperature impregnations for electric and electronic parts.

Room temperature viscosity of R-7521 silicone resin is 100 centistokes, compared with 2500 centistokes for epoxy resins. The low viscosity of the resin is said to permit quick saturation and pene-



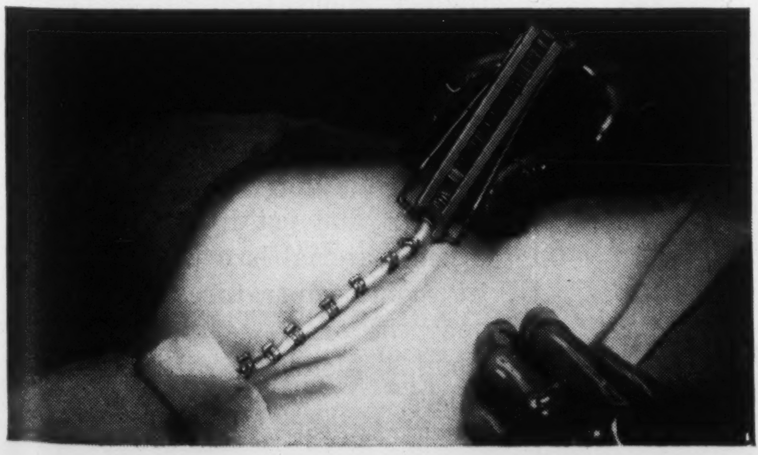
Above: The various steps in forming Autoclips® from Anaconda 18% Nickel Silver strip, .637″ wide by .013″ thick. Below are individual Autoclips and those mounted in wire holders ready for insertion in Autoclip Applier, at left. Exclusive wholesale distributor for Autoclip is Clay-Adams, Inc., New York City. ***Below, left:*** Autoclips being used to attach skin towel to edges of incision.

Anaconda Technical Service helped in

Selecting the exact Nickel Silver strip for this surgical clip

THE PROBLEM: The Technical Oil Tool Corporation, Los Angeles, developed Autoclip, an automatic magazine-type clip and applier to close wounds or incisions faster and easier. Selecting the right metal for the clip was the problem. A certain amount of tension was required to hold the wound edges together during healing, with the least amount of damage to tissues. In addition, the clip had to open easily for painless removal. The metal should be easy to form, and retain sharp, die-cut edges.

THE SOLUTION: After several unsuccessful attempts with various metals, sample clips of the required gage were made of Nickel Silver. These silvery white copper-alloys have excellent resistance to corrosion in service or in storage and have been time-tested for surgical instruments and equipment. Technical specialists of The American Brass Company suggested Nickel Silver, 18%-719—one of four standard Anaconda Nickel Silver Alloys—as the one best suited to meet all the requirements including tension, formability, clean edges and sharp points.



FREE TECHNICAL SERVICE: Metallurgists and technical specialists in The American Brass Company, through their day-to-day work with a great variety of metal problems, offer a tremendous breadth of experience. And this experience is at your disposal—to help you select the exact alloy, form, temper for your job. Call your American Brass Company representative, or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

5769

ANACONDA®

COPPER, BRASS, BRONZE *and* NICKEL SILVER

Made by The American Brass Company

For more information, turn to Reader Service card, circle No. 416

A NEW FREEDOM IN BEARING APPLICATIONS

Availability of Sintered Powdered Metal Bearings and machine parts from a fully competent and technically responsible source opens the way to improvements in mechanical products.

Bunting facilities for designing, engineering and manufacturing of Sintered Powdered Metal Bearings and parts are as comprehensive and responsible as the traditional Bunting competence in the field of Cast Bronze Bearings.

A competent group of Bunting Sales Engineers in the field and a soundly established Product Engineering Department put at your command comprehensive data and facts based on wide experience in the designing and use of Cast Bronze and Sintered Powdered Metal Bearings and parts.

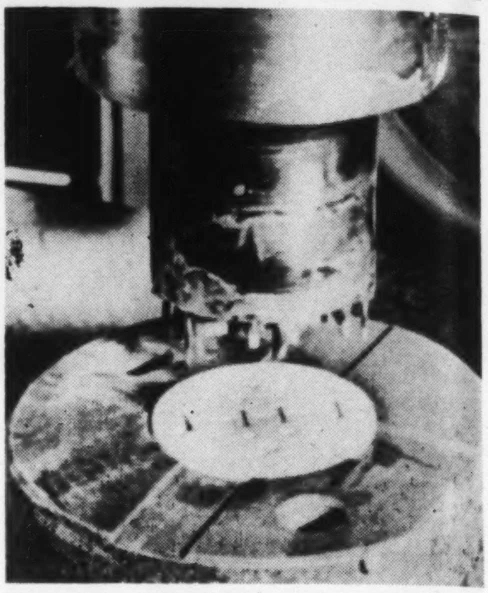
Write for catalogs and your copy of the new 24 page Bunting Engineering handbook of Sintered Powdered products and their composition, manufacture and application.

Bunting®

BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities

For more information, turn to Reader Service card, circle No. 424

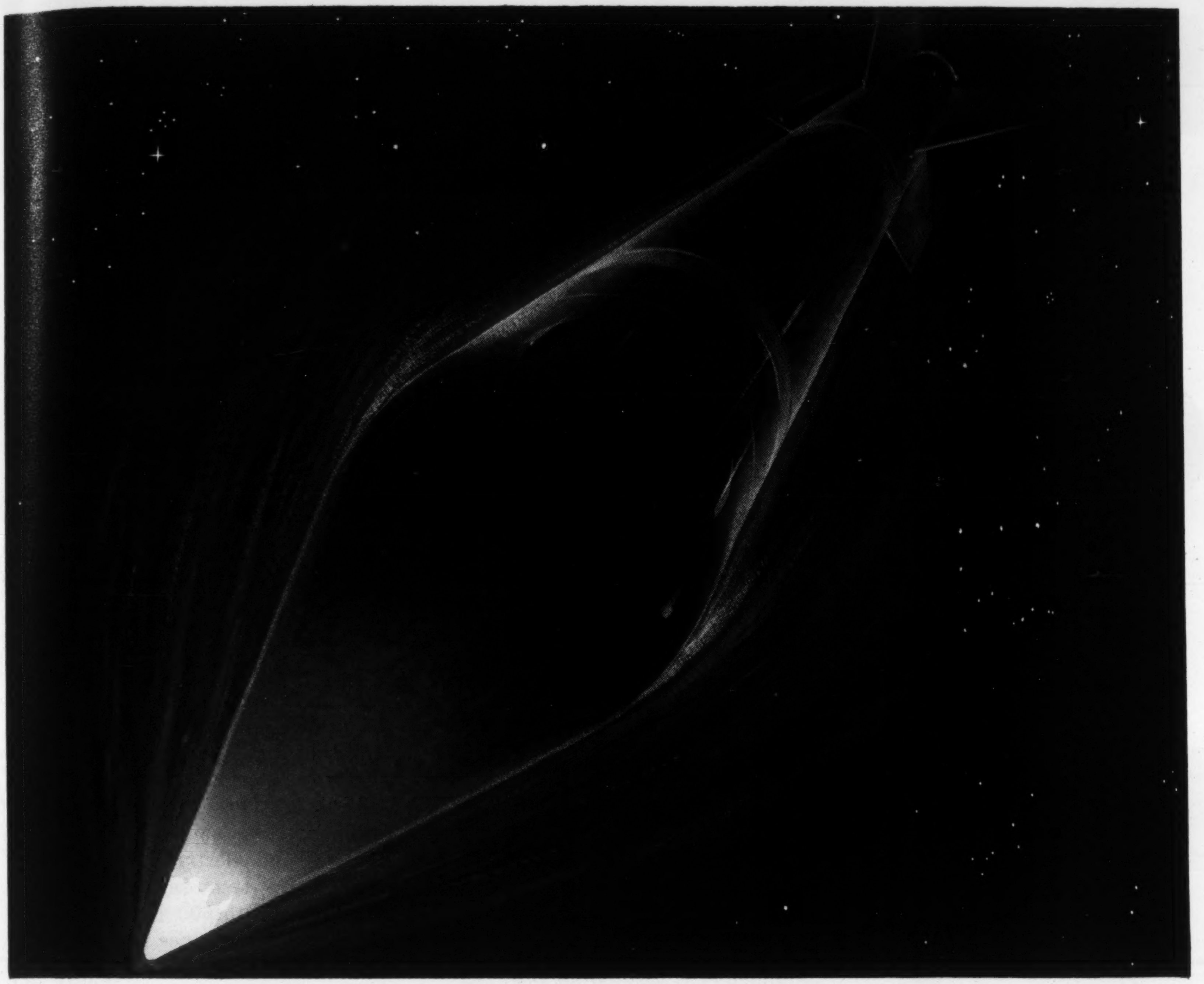


Intricate ceramic parts—Volume production of close tolerance ceramic parts with intricate configurations is now possible with a unique ultrasonic drilling technique. The technique uses an electro-mechanical transducer that converts alternating current into mechanical force to vibrate an impact tool at 25,000 cps. Particles of abrasive in a slurry are driven with tremendous impact to reproduce an exact counterpart of the tool face in the ceramic workpiece. As a result, intricate orifices, multiple arrangements of holes and slots, and other complex configurations are cut into the ceramic workpiece in a single operation.

tration of complex electronic assemblies. Resin R-7501 has a room temperature viscosity of 2500 centistokes and can be blended in any ratio with R-7521 to provide desired viscosities. The resins can be thinned by warming to 175 F before application.

Full cure of the resins is obtained with a peroxide catalyst and a step cure of 9 hr at temperatures up to 390 F. Shelf life of the uncatalyzed resins is over a year, and pot life of the catalyzed material is over six months at room temperature. The resins may be used as potting compounds, alone, or with inorganic fillers.

The cured resins are said to



Sustained operating temperatures up to 400° F, as in guided missiles, are death to inferior electrical insulations and laminates. CDF glass-base laminates of Teflon*—the only laminates of their kind approved by the military—can take this punishment steadily.

LATEST HIGH-HEAT INSULATION SYSTEMS NEED CDF GLASS-BASE LAMINATES AND TAPES

Widest available range offers Teflon, epoxy, silicone, mica products for dimensional stability under continuous heat

As components and equipment grow smaller, and heat becomes more difficult to dissipate, CDF high-heat electrical insulations become increasingly important to electronic design. For nowhere else can such a wide range of quality insulations be found under one roof as at CDF.

FOR HIGH-HEAT PRINTED CIRCUITRY, CDF glass-base metal-clad laminates of Teflon* and epoxy exhibit best dimensional stability and current-carrying capacity. Constant operating temperatures of 300°F — soldering temperatures to 500°F — are readily met by these specialized CDF Dilecto® laminates.

HIGH-HEAT FLEXIBLE INSULATIONS. CDF offers a wide choice of insulating tapes made of Teflon, silicone varnish, silicone rubber, and Micabond®, with glass-cloth support. CDF tapes may be used either by hand wrapping or on automatic winding machines. Unsupported Teflon in colors available to meet MIL-STD 104.

TEFLON SPAGHETTI TUBING AND OTHER SPECIALTIES. Part of CDF's vast fabrication facilities is devoted to the production of custom parts from Teflon — spaghetti tubing, rods, sheets, and machined parts to rigid specifications.

NEW — *cementable* Teflon, bondable to itself and to other materials with commercial adhesives.

SEE SWEET'S Product Design File, Electronics Buyers' Guide, and other directories for the name and phone number of your CDF sales engineer. Then send your print or your problem, and we'll return specific technical data and test samples.

*trademark of DuPont tetrafluoroethylene resin

CONTINENTAL-DIAMOND FIBRE
A SUBSIDIARY OF THE Budd COMPANY • NEWARK 25, DEL.

For more information, turn to Reader Service card, circle No. 526

now

Kurz-Kasch announces an important development; the ability to *mold* epoxy parts—in intricate shapes, with inserts—in large production quantities, with molding cycles and economy comparable to conventional thermosetting materials.

epoxy

The material is molded by techniques developed by Kurz-Kasch from resinous materials supplied by Booty Resineers Inc., Newark, Ohio.

molded

It is no longer necessary to limit yourself to casting procedures to get the benefits of epoxy. Molding cycles are relatively fast; production costs are therefore low. Tooling costs are comparable to other high-pressure plastics.

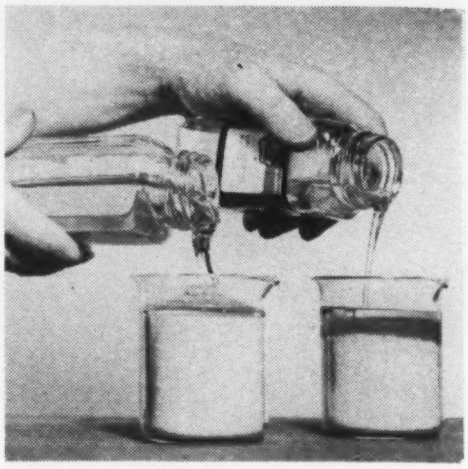
parts

These parts have exceptional toughness, ability to hold inserts, resistance to moisture and most chemicals, and excellent insulating properties. Call your nearby Kurz-Kasch representative for quotes on parts molded of this material to your specs. Kurz-Kasch, Inc., 1415 South Broadway, Dayton 1, Ohio.

kurz-kasch

New York, Mt. Vernon, Mo 4-4866; Rochester, Hillside 0626; Beverly, Mass., Walker 2-0065; Atlanta, Cedar 7-5516; Chicago, Gladstone 6-8837; Detroit, Jordan 6-0743; Philadelphia, Hilltop 6-6472; Dallas, Lakeside 6-5233; Pasadena, Ryan 1-6774; Minneapolis, Walnut 6-2749; St. Louis, Parkview 5-9577; Toronto, Oliver 7986

For more information, turn to Reader Service card, circle No. 460

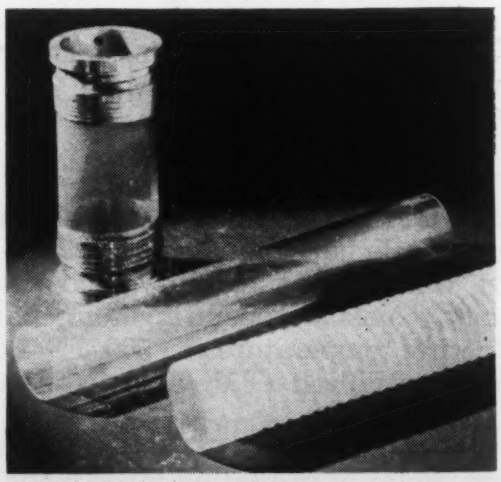


***Silicone resin** (right) penetrates sand in much less time than epoxy resin (left).*

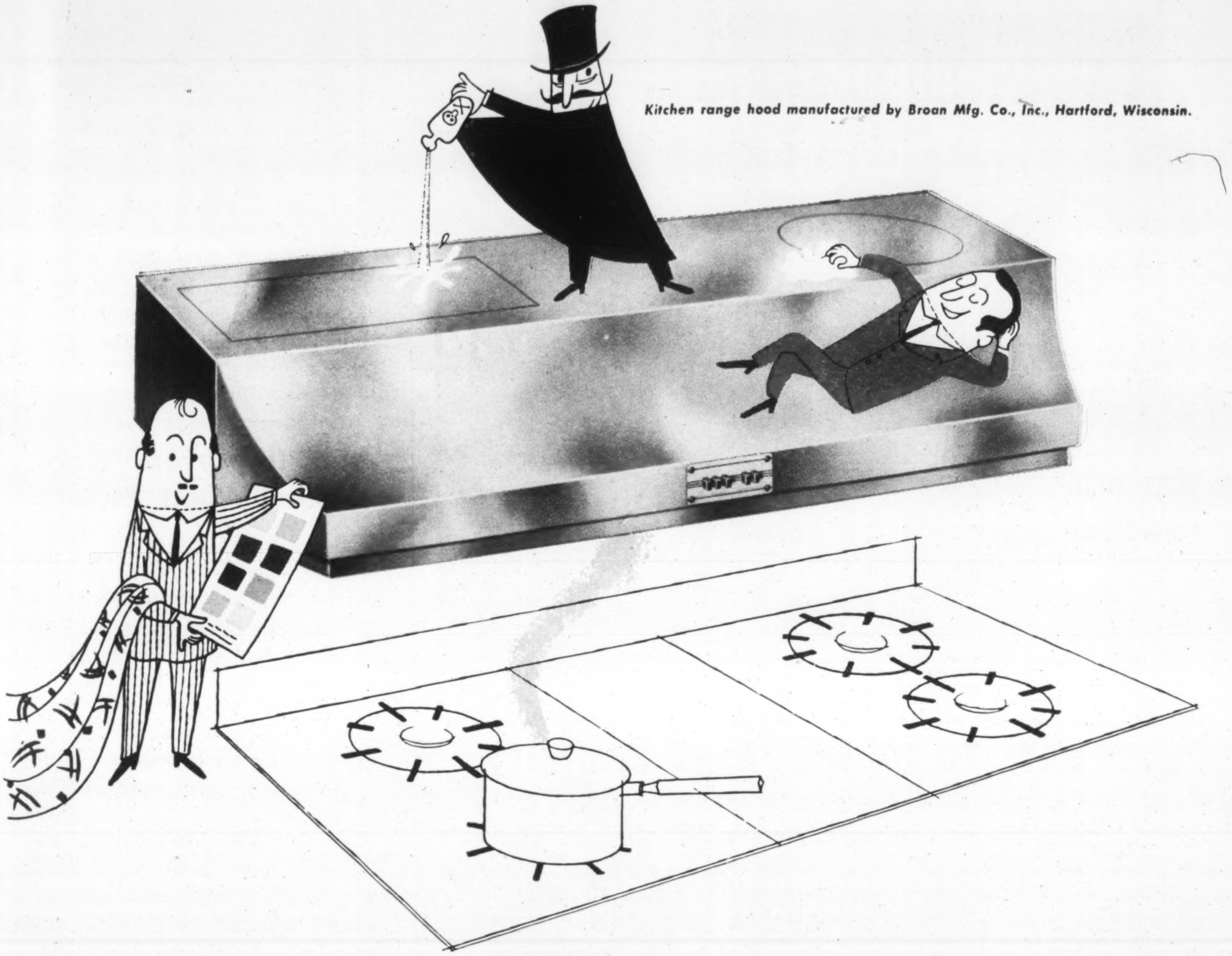
have good dielectric and mechanical properties, good moisture resistance, and good thermal conductivity after prolonged exposure at temperatures of 400 F. The resins are also said to have good physical and electrical properties after intermittent service at temperatures up to 500 F. They are recommended for use in aircraft transformers, motors and electronic assemblies.

Fluorocarbon Tubing Made in Large Sizes

Transparent, seamless tubing of Kel-F fluorocarbon plastic, is available in diameters from 2 to 6 in. and in lengths up to 12 in. from Combs Engineering & Mfg.



***Flexible plastics tubing** can be used as bellows.*



Kitchen range hood manufactured by Broan Mfg. Co., Inc., Hartford, Wisconsin.

Blends with all colors–resists acids–easy to clean

You get all 3 with products made of Crucible stainless

They're 3 selling advantages that put any product made of Crucible stainless steel way out ahead of the competition. This stainless steel exhaust hood, for example, cleans faster than any other kind. It has an eye-catching, smooth, shiny surface that withstands almost anything—even acids. And stainless steel's glitter-grey look blends with any color—anywhere. In fact, Crucible stainless enhances other colors by reflecting them. (Think how dealer inventories drop when 1 color satisfies all needs.) And think how far ahead your product would be with these selling advantages of Crucible stainless steel. To find out more about Crucible stainless, write for the handy Crucible Stainless Steel Selector. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

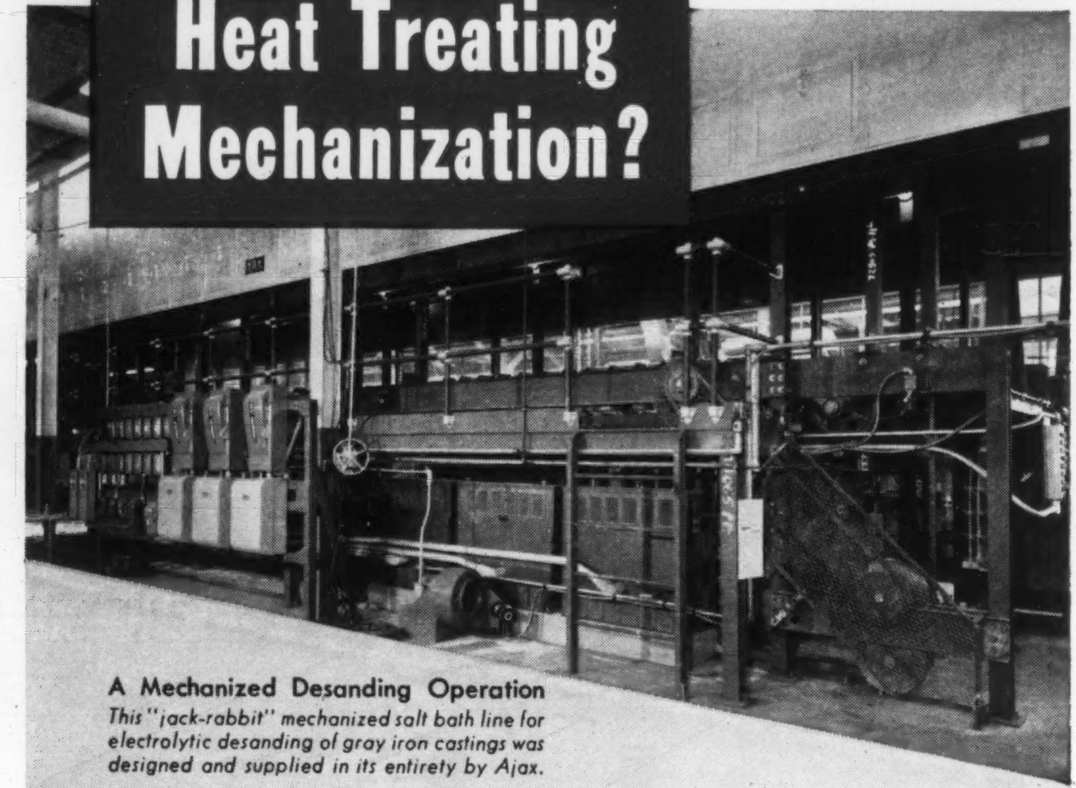
CRUCIBLE **first name in special purpose steels**

Crucible Steel Company of America

Canadian Distributor—Railway & Power Engineering Corp., Ltd.

For more information, turn to Reader Service card, circle No. 538

Planning
Heat Treating
Mechanization?



A Mechanized Desanding Operation
This "jack-rabbit" mechanized salt bath line for electrolytic desanding of gray iron castings was designed and supplied in its entirety by Ajax.

. . . IT PAYS TO CONSULT AJAX ELECTRIC!

The extent of Ajax Electric experience in applying salt baths to specific heat treating problems is evident in the Ajax engineering of mechanized installations, large and small.

In hundreds of applications, complete heat treating cycles are handled automatically by conveyorized installations engineered from beginning to end by Ajax.

You get more than just salt baths from Ajax. You get complete heat treating know how . . . accurately applied to your specific problem!

AJAX® HULTGREN electric SALT BATH furnaces

AJAX ELECTRIC COMPANY
906 Frankford Avenue Philadelphia 23, Pa.
Associates: Ajax Electrothermic Corp., Ajax Engineering Corp.

LET THESE AJAX REPRESENTATIVES HELP SOLVE YOUR HEAT TREATING PROBLEMS!

ARLINGTON, TEX.: T. E. Nicklas Company, 1015 Inwood Drive, P.O. Box 92 Crestview 4-7139
ATLANTA 9, GA.: C. B. Rogers Associates, 1000 Peachtreet St., N.E., P.O. Box 7086 Station C—Trinity 5-8196
BALTIMORE 15, MD.: Edward R. Talone, 4313 Elderon Ave.—Forrest 7-6799
CLEVELAND 13, OHIO: Anderson-Bolds, Inc., 2012 W. 25th St.—Prospect 1-7112
DENVER 2, COLORADO: E & M Equipment Co., 2415—15th St.—Glendale 5-3651
DETROIT 35, MICH.: J. E. Bullock, 19449 James Couzens Hwy.—B'way 3-1211
ELMHURST, ILL.: O. M. Haseltine, 129 N. York St.—Terrace 2-7107
GLENSIDE, PA.: John P. Clark, Jr., 124 S. Easton Rd.—Turner 7-1776 or 1777
GOSHEN, OHIO: Ralph D. Hawkins, Box 196—Parkway 1-6444
HAMDEN 18, CONN.: Joseph M. Halloran, 63 Mowry St.—Chestnut 8-3069
LOS ANGELES 22, CALIF.: A. W. Nash, 2112 S. Atlantic Blvd.—Angelus 9-7304
MOUNTAIN LAKES, N. J.: Roger Stuart Brown, 7 Point View Place—Deerfield 4-0578
NASHVILLE 4, TENN.: H. R. Miles & Assoc., 2508 Franklin Rd.—Cypress 2-7016
NEW YORK 6, N. Y.: Roger Stuart Brown, 136 Liberty St.—Rector 2-9638
ORINDA, CALIF.: George H. Thurston, 1 Estates Court—Clifford 4-5411
PITTSBURGH 22, PA.: McQuiston & Gibson, 310 Renshaw Bldg.—Atlantic 1-3721
SEATTLE 4, WASH.: H. E. Hartley, 230 Hudson St.—Mohawk 7120
TONAWANDA, N. Y.: A. C. Towne, Jr., Charles Percival, Jr., 1456 Niagara Falls Blvd.—Amherst 1468

For more information, turn to Reader Service card, circle No. 454

Co., 428 S. Cherry St., Wallingford, Conn. According to the producer, wall thicknesses of 0.060 to 0.80 in. provide good high pressure resistance. The plastics tubing is suitable for use in fuel gages.

New, Improved Paints Protect Wood, Metals

Seven new, improved coatings and paints have been developed during the past months. The developments range from a refractory coating for steel mills to a chromate coating for zinc, cadmium and copper. A brief description of each follows:

1. Coating for plastics

An epoxy resin compound has been introduced by Smooth-On Mfg. Co., 572 Communipaw Ave., Jersey City 4, N. J., as a coating for plastics laminates and as a lining material for chemical tanks and barrels. Called Sonite SC-1, the material when cured has a Rockwell hardness of 75, a tensile strength of 23,000 psi, and an edgewise compressive strength of 25,000. The epoxy compound, light yellow in color, is said to have a storage life of at least 12 months in a closed container. About 0.4 lb are required to apply a 1/16-in. coating to 1 sq ft of surface.

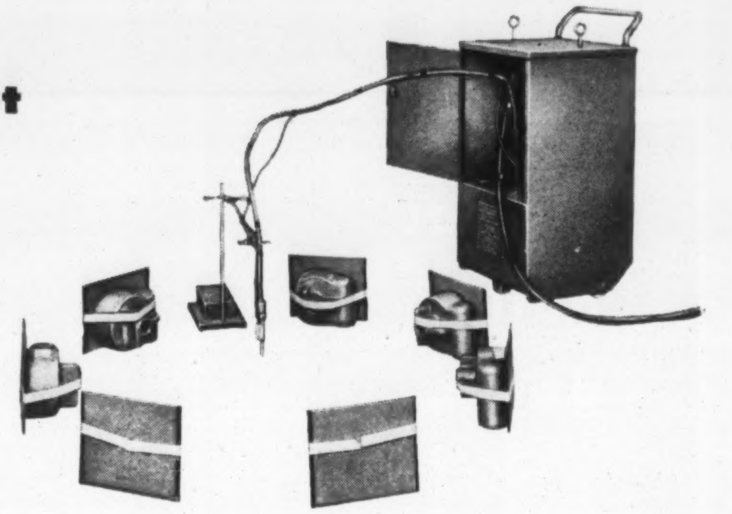
2. Coating for wood

A series of vinyl coatings, designated Lankote 200-H and produced by J. Landau & Co., Inc., Washington Ave., Carlstadt, N. J., can be sprayed at full solids content (45% by weight) with either hot or cold spraying techniques. The heavy coating material is said to offer high film thickness per pass, good corrosion resistance, low application cost and long life. According to the producer, the coatings are nontoxic, odorless, tasteless and nonflammable. They adhere fairly well to ferrous metals and very well to wood, plaster

some people have queer notions about

RADIOGRAPHY WITH ISOTOPES

Many a plant, uneasily aware that it is missing the profits of radiographic inspection, still holds back for one mistaken "reason" or another. Here are some we run into . . .



Here's a typical multiple-specimen setup . . . seven castings radiographed simultaneously with a T.O. model 402 panoramic Cobalt 60 unit.

"out of my league". . . *costs too much*

Not so. An iridium 192 machine costing as little as $1700 may be fully adequate to your needs. *Indeed, average equipment cost is less than $2500.*

needs a *specialist* to run

On the contrary, a practical on-the-job training course in our Cleveland laboratory (free tuition to buyers) equips any intelligent employee with all he has to know.

takes forever to make a radiograph

Not so. You can x-ray 1" steel in 30 seconds, 3" sections in 4 minutes with the Cobalt 60 sources available today.

gamma radiographs are no good

Not so. If you use the right source for the right job you'll have no trouble getting the 2% detail sensitivity required by exacting inspection codes.

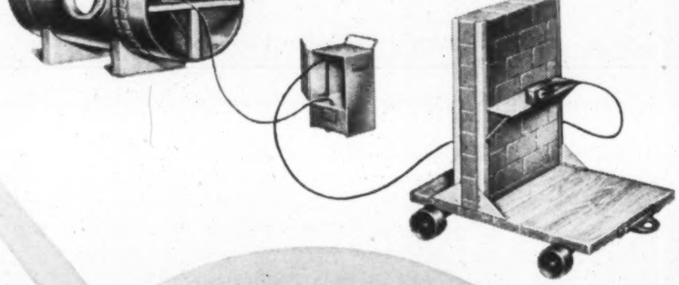
it's dangerous; we're afraid of it

No reason to be: Technical Operations modern equipment is safe and simple-to-handle.

not for me; my stuff is different

We don't know what *your* business is . . . but if *whatever* you make (or buy or sell) needs "seeing into" for quality control, radiography (either gamma or x-ray) can profit you as it does others — *your competitors included.*

The compact source capsule easily enters into pipes and hollow vessels to radiograph "inside out."



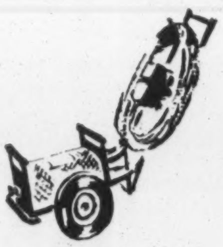
costs nothing to find out

what radiography can do for you. Simply call in your local Picker representative* or write us outlining your problem (and if possible, sending typical samples). We'll make tests and tell you frankly whether radiography holds any promise for you. Because Picker offers *both* x-ray and isotope equipment, we have no axe to grind for any particular method.

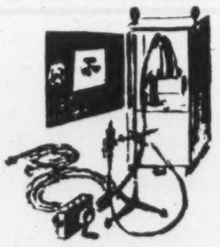
***There's probably a Picker district office near you (see local 'phone book)**

PICKER X-RAY CORPORATION
25 South Broadway, White Plains, N. Y

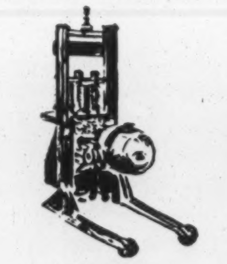
SOME OF THE TECHNICAL OPERATIONS GAMMA RADIOGRAPHY UNITS MARKETED AND SERVICED BY PICKER X-RAY



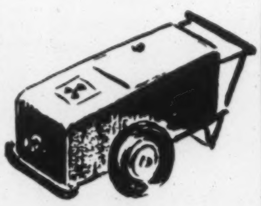
TO412A
Iridium 192 Unit



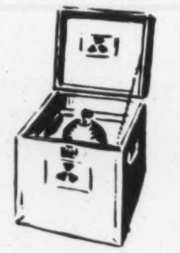
TO402
Cobalt 60 Unit



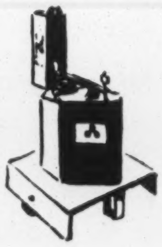
TO404
Cobalt 60 Unit



TO446
Cobalt 60 Unit



TO405
Iridium 192 Unit



TO416
Source Changer

one stop for everything in Picker x-ray **radiography and fluoroscopy**

For more information, turn to Reader Service card, circle No. 549

It's not nailed down, It's Fansteel 77 Metal

NSTEEL
CTRONICS BEGINS IN METALS
IT'S NOT NAILED DOWN
IT'S FANSTEEL 77 METAL

Show-goers at the Fansteel Exhibit are invariably astonished by the weight of 77 Metal. Many assume that it is actually "fastened" to the display table.

Fansteel 77 Metal's startling weight provides the solution to many engineering problems . . . especially those concerning inertia or momentum, counter balancing, vibration control and shielding. Its use is recommended whenever the objective is . . .

Maximum Density in Limited Space

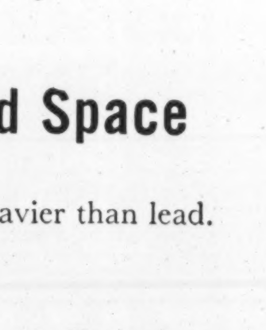
HOW HEAVY? *Twice* as heavy as steel, 50% heavier than lead. (.613 lbs. per cubic inch.)

HOW STRONG? Tensile strengths to 140,000 psi. Transverse rupture to 270,000 psi. Elongation to 10%.

HOW EASILY MACHINED? Machines like cast iron . . . takes fine finishes, close tolerances.

HOW ECONOMICAL? Made by powder metallurgy of pure tungsten, copper and nickel, waste of materials is limited, machining costs are cut.

Fansteel 77 Metal Is The Ideal Material For Use In . . . *Aircraft aileron counterweights, Rotors, Governors, Balance Weights of all types, Radiation Shielding, Vibration Damping Devices.*



Write for this free booklet

K565A

FANSTEEL METALLURGICAL CORPORATION
NORTH CHICAGO, ILLINOIS, U. S. A.

For more information, turn to Reader Service card, circle No. 531

and concrete. The coatings are available in a number of colors.

3. Coating for hot steel

A new refractory coating called Metal Part has been developed to shield metal surfaces that come in contact with molten metal and slag. Developed by H. K. Porter Co., Inc., Refractories Div., 2500 First National Bank Bldg., Pittsburgh, Pa., the coating can be applied to hot metal surfaces (700 F max). Containing graphite, calcined aggregates and minerals, the paint can be used to coat steel ingot stools, slag pots and ingot buggy couplings.

4. Coating for die castings

Conversion Chemical Corp., Rockville, Conn., has announced the development of a chromate finish that produces iridescent films on zinc, cadmium, copper, brass and zinc die castings. The product may be adjusted to give different iridescent bronze shades by varying plating bath pH, concentration and immersion time. According to the producer, corrosion protection afforded by the coating is ample to meet all government coating specifications.

5. Coating for machinery

A vinyl enamel coating that can be applied to machinery without interrupting work schedules has been developed by Wooster Finishes Corp., Wooster, Ohio. Called Vinyl Enamel, the plastics emulsion is nonflammable during application and fire resistant when dry. It is said to possess a nonoffensive, nontoxic odor that is not noticeable to workmen in adjoining areas. It dries to the touch in 1 hr and is dust-free in 4 hr. According to the producer, the coating forms a hard, glossy finish that resists damaging effects of oil, grease, industrial fumes, excessive moisture and mild acids. It is reported to last for a number of years without deterioration.

6. Coatings for boats

Two new coating materials, a maintenance paint and a clear

Breaking fabrication barriers in new materials with cold forging!

Magnesium,
Oxygen-free Copper,
Zirconium,
High Strength Aluminum Alloys

Most companies and engineering personnel are well acquainted with Hunter Douglas' activities in the field of cold forging aluminum and aluminum alloys. Not so well known are our efforts in the production of magnesium and oxygen-free copper components by the same process. Recently, as the result of a concentrated Hunter Douglas research program, tubular zirconium was successfully cold-forged...an achievement which now opens the door to the fabrication of other rare and costly metals by our cold forging techniques.

The field of cold forging is constantly expanding with many new successes destined for the future.

Where stakes are high and being "first" assures a competitive advantage—in lower cost, better design, greater strength—an original approach to your fabrication problem will pay dividends.

Hunter Douglas cold forging techniques, backed by an unmatched experience in this field, frequently supply the missing key. Many fabrication problems can be solved simultaneously by producing hollow, dense, zero-draft components meeting exact part geometry requirements and difficult performance specifications.

If you have production requirements in any of the metals now being regularly cold forged, we welcome the opportunity of reviewing prints and submitting quotations. Especially important, *if you have an advanced program involving zirconium or other rare metals,* we are in position to devote development facilities to the solution of specific high priority problems.

HUNTER DOUGLAS ALUMINUM

Among Hunter Douglas' many achievements is the first successful cold forging technique for zirconium ...a metal long believed unresponsive to this process!

By cold forging, the hard surface oxides, carbides and nitrides normally produced by hot working were completely absent, surface finish was good, and in tubular shapes tolerances on diameters and concentricity were held to a few thousandths... far superior to hot extrusions. With almost complete elimination of machining, metal waste was negligible... an extremely important factor with material costs running as high as $20.00 per pound!

Cold forging of oxygen-free copper is now proving important to the electronics industry and experimental development work is in progress on magnesium and even common metals, such as steel. Out of this extensive research program is coming the vital knowledge for meeting tomorrow's unusual problems. Look to Hunter Douglas for everything new in cold forging!

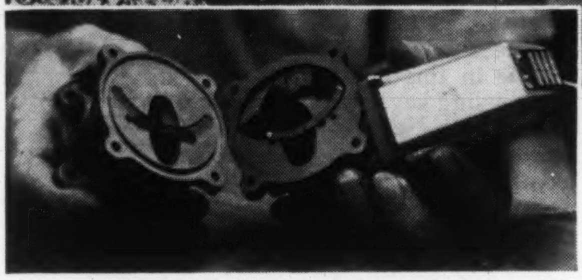
Hunter Douglas HD Aluminum

Division of BRIDGEPORT BRASS COMPANY

Dept. MM-9, Riverside, California, Telephone OVerland 3-3030

For more information, turn to Reader Service card, circle No. 415

U.S. AIR FORCE
42



SELF-LUBRICATING, long-wearing parts molded from Nylatron GS molybdenum disulphide filled nylon powders are selected for new series of aircraft and missile fuel pumps.

Parts from NYLATRON® GS Molding Powders meet critical aviation requirements

● Performance specifications laid down by the aviation industry demand the very best in materials and design. Parts molded from Nylatron GS were chosen over other materials for this important component after demonstrating these outstanding characteristics:

Exceptional Dimensional Stability
Low coefficient of linear expansion and minimum distortion after molding, provides accurate, close tolerance molding.

Low Surface Friction
When wear parts must run dry, Nylatron GS parts operate without lubrication.

High Wear and Abrasion Resistance
Part surfaces resist abrasion and demonstrate long wear in contact with metals.

High Heat Distortion Temperature
Nylatron GS parts provide higher modulus of elasticity and higher heat distortion temperatures than standard nylon 101.

Chemical Resistance
Nylatron GS parts are unaffected by hydrocarbons including JP4 fuel.

NYLATRON GS nylon molding powder is a molybdenum disulphide filled nylon* developed to expand the field for nylon parts. It is produced by National Polymer Products, Inc., a subsidiary of The Polymer Corporation, Reading, Pa. Latest technical data or guidance in using Nylatron GS is readily available in answer to your request.

**Patents applied for*

NATIONAL POLYMER PRODUCTS, INC.
A Subsidiary of The Polymer Corporation, Reading, Pennsylvania
Export: Polypenco, Inc., Reading, Penna., U.S.A.

POLYPENCO®

For more information, turn to Reader Service card, circle No. 443

PROPERTIES OF MARASET PAINTS

Type ➔	No. V760	No. 750
Total Solids, %	32	57.6
Coverage, sq ft/ gal	600	500
Sward Hardness	50	50

varnish, have been introduced by Marblette Corp., 37-31 30th St., Long Island City 1, N. Y. According to the producer, both paints have been successfully tested in the chemicals, petroleum, automotive, maritime and other industries.

The maintenance paint, called Maraset No. 750, protects piping and equipment from the corrosive action of fumes, fluids, fuels and salt sprays. Recent tests show that No. 750 paint is unaffected by one month's immersion in solvents, salt water and dilute acid and alkali solutions.

The clear varnish, called Maraset No. V-760, is said to improve the appearance of natural wood grain on boats and chromium trim on automobiles.

Supplied with catalyzed thinners, both paints cure at room temperature and are particularly useful when the equipment to be protected is too large for an oven cure. They can be applied to automobile bodies, marine and oilfield equipment, gasoline pumps, tank interiors, outdoor furniture and various types of machinery.

Modified Acrylic Has High Impact Strength

A modified acrylic molding powder called Implex has been introduced in limited quantities by Rohm & Haas Co., Washington Square, Philadelphia 5, Pa. According to the producer, production is to be stepped up later this year and should reach full-scale commercial volume late in 1958.

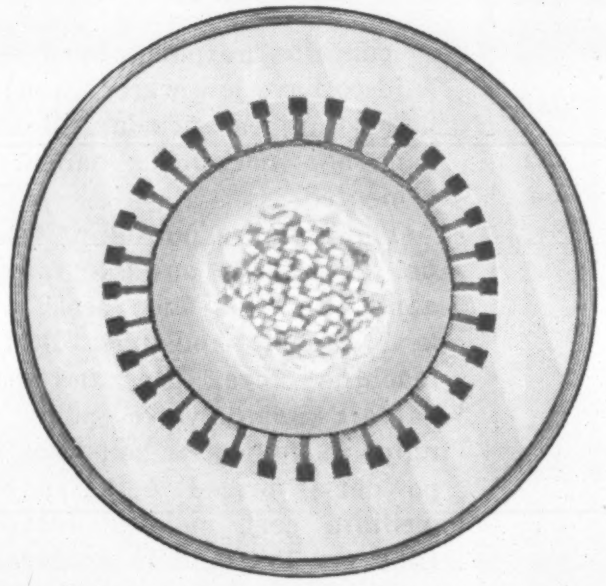
The new product has high impact strength, good stability, and

SEPTEMBER
1957

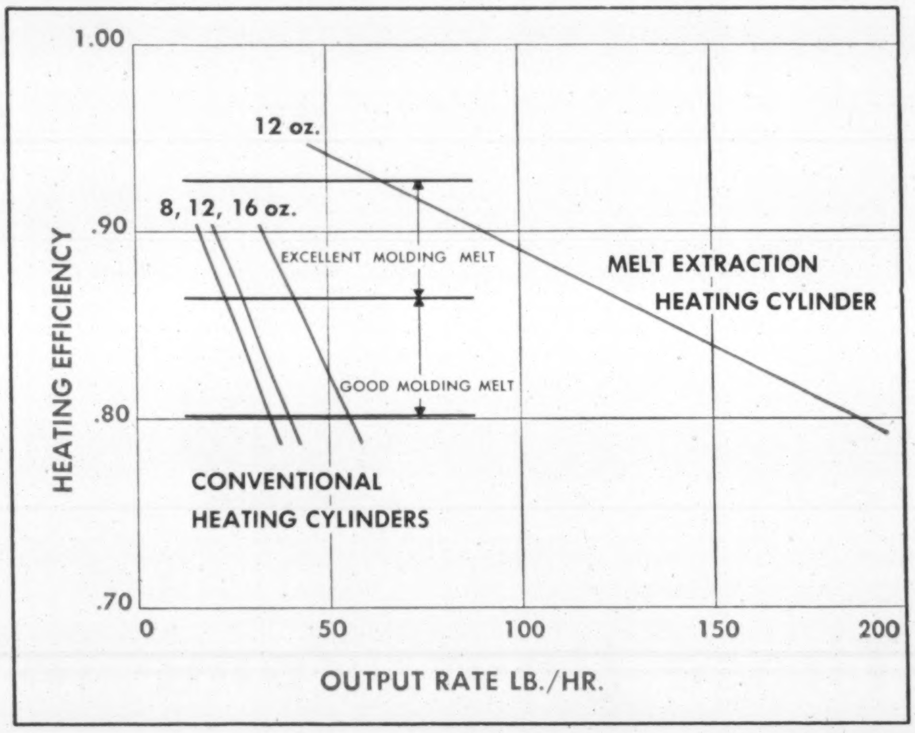
Plastiatrics

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

PLASTIC STOCK TEMPERATURE CRITICAL FACTOR IN INJECTION MOLDING



Melt extraction heater, above, is a cylindrical device with exterior longitudinal grooves. Bottom of each groove has many perforations to provide passage to the groove. When cold plastic granules enter center of liner, they touch hot wall, melt and flow through holes to the groove and then forward to injection nozzle. Device replaces the torpedo of a conventional heating cylinder.



A melt extraction heater produces more than three times as much melted plastic at 0.8 efficiency as an average conventional heater of comparable size.

INCREASED EFFICIENCY OF MELT EXTRACTION HEATERS PROVIDES UNIFORMLY PLASTICIZED MOLDING MATERIALS

Melt extraction heating of thermoplastics shows promise of overcoming a long-recognized problem for injection molders . . . that of providing a steady flow of uniformly plasticized material to the mold cavity. The design of a melt extraction heater eliminates the need to transfer heat through the plastic. Uniform temperature distribution in the plastic is assured because the means of removing the plastic from the heated surface restricts the material removed to that which is well melted (see illustration above). When the plunger exerts pressure on the granules, the fluid polymer next to the inside surface of the liner flows through the holes into the grooves and through the nozzle to the mold.

The advantages of providing uniformly plasticized material are several. Silver streaking, caused by overheating in localized areas can be eliminated. And discoloration and brittleness of plastic parts, associated with degradation of the polymer, may be reduced with uniformly plasticized material.

The design and development of more efficient melt extraction heaters is one area now under study by Dow Plastics Technical Service engineers.

This is but one of a continuing series of Plastiatrics studies which cover every phase of plastics formulation, design, molding and finishing.

Send for Dow Technical Service bulletin entitled "Uniformity Considerations for Plastic Stock Temperature in Injection Molding" and a list of other areas under investigation. Write THE DOW CHEMICAL COMPANY, Midland, Mich., Plastics Sales Dept. 1545P.

AMERICA'S FIRST FAMILY OF POLYSTYRENES

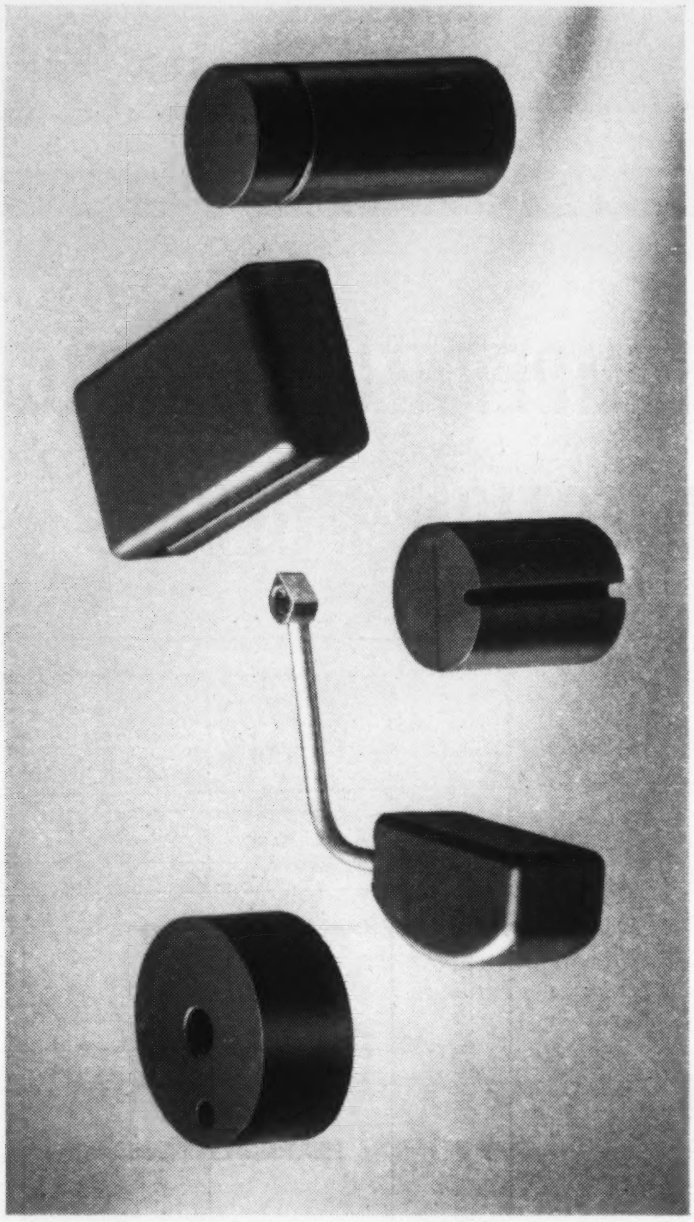
GENERAL PURPOSE
- STYRON® 666
- STYRON 666M (Easy Flow)
- STYRON 665 (Extrusion)
- STYRON 689 (Easy Flow)

HIGH IMPACT
- STYRON 475
- STYRON 475M (Easy Flow)
- STYRON 777 (Medium Impact)
- STYRON 440 (Heat Resistant)
- STYRON 480 (Extra-High Impact)

HEAT RESISTANT
- STYRON 683
- STYRON 700

YOU CAN DEPEND ON DOW

For more information, turn to Reader Service card, circle No. 559



These floats come in one piece and stay that way

Floats made by Rogers are molded in one piece of cellular rubber, an exceptionally buoyant material composed of myriads of sealed, gas-filled cells. The floats are puncture-proof, homogeneous and uniform. Ridges, slots, grooves and other three-dimensional requirements are integrally molded. Levers can be attached during molding.

Just as important, the rubber used for your floats is specifically formulated to withstand attack by the chemicals it will contact. Fluid absorption is so low as to be insignificant—the sealed, gas-filled cells present a virtually impenetrable barrier to liquids. You get a float that stays afloat indefinitely.

You can—as others are already doing—improve fluid control with Rogers floats. We welcome special requirements. Write Dept. M, Rogers Corporation, Rogers, Conn., for further details.

ROGERS
CORPORATION
ROGERS CONNECTICUT

DUROIDS • SHOE MATERIALS • ELECTRICAL INSULATION • PLASTICS • RUBBER • FABRICATING • DEVELOPMENT

For more information, turn to Reader Service card, circle No. 448

PROPERTIES OF IMPLEX

Tensile Strength, psi	5200
Modulus of Elasticity, psi	220,000
Elongation, %	30
Flexural Strength, psi	8000
Specific Gravity	1.12
Heat Distortion Temperature, F	194
Water Absorption (24 hr), %	0.3

good heat and stain resistance. It contains no plasticizers and is said to have low water absorption and no unpleasant odor. Moldings can be machined, nailed and cemented.

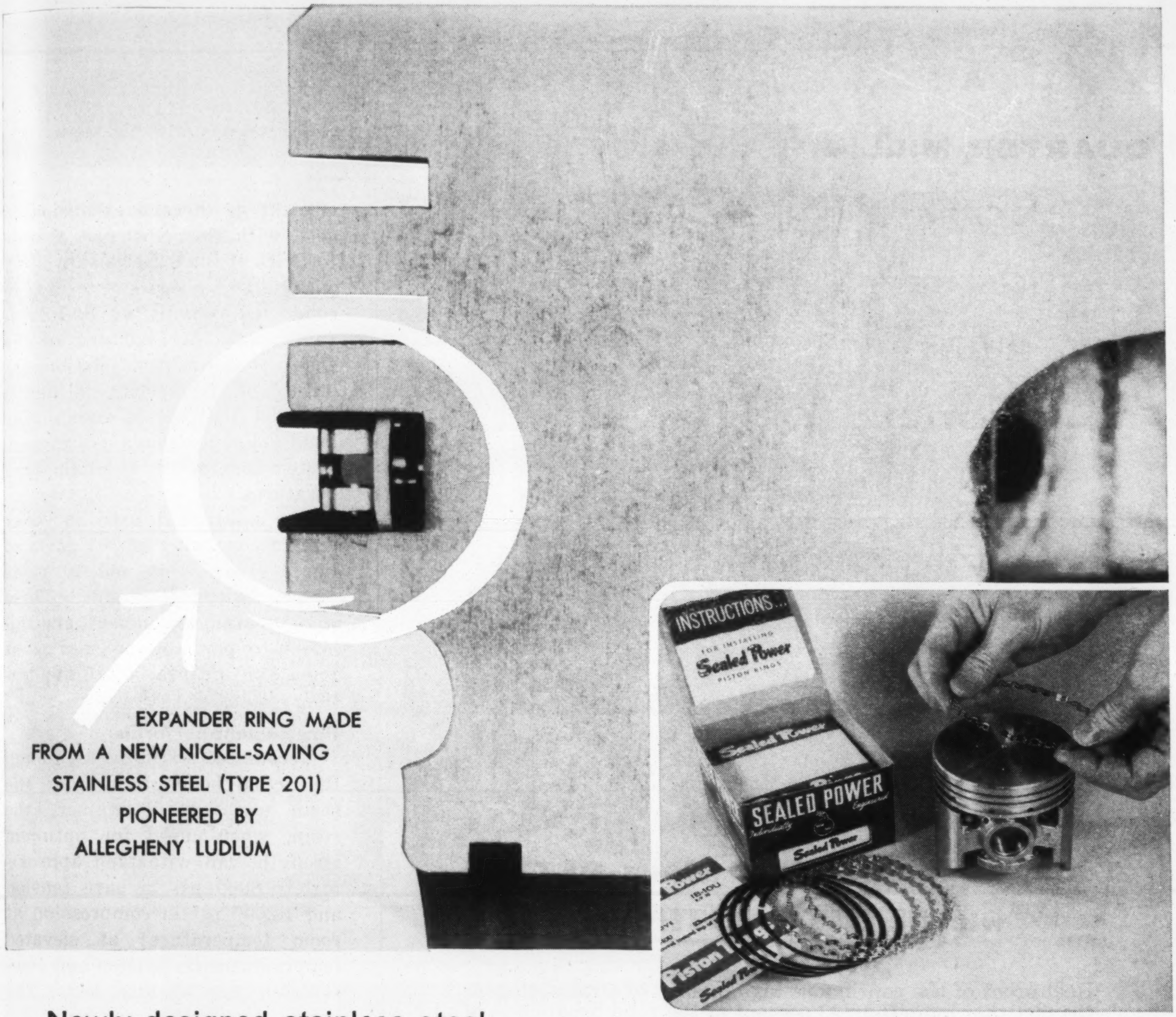
The molding powder is said to be particularly suitable for such applications as shoe heels, piano keys, razor housings, business machine keys, pen and pencil parts, knobs, valve parts and numerous types of housings. The powder is priced in the range of medium cost molding materials (56¢ per lb), and is produced in white and in various colors.

Epoxy Cement Seals High Vacuum System

Recent research shows that an epoxy cement gives air-tight bonds between similar and dissimilar materials in high vacuum systems operating at high temperatures.

At high temperatures two problems usually arise which limit the use of such conventional sealing materials as waxes and greases. One is that dissimilar expansion rates of unlike materials create strains within the bond which result in a mechanical weakening of the joint and loss of the air-tight seal. The other is that vapor pressure of the sealing material increases as the temperature increases and the system reaches an equilibrium pressure limit.

From these two considerations it is obvious that a vacuum cement should have an extremely low vapor pressure at operating temperatures and a balanced co-



EXPANDER RING MADE
FROM A NEW NICKEL-SAVING
STAINLESS STEEL (TYPE 201)
PIONEERED BY
ALLEGHENY LUDLUM

Newly-designed stainless steel

OIL RING ASSEMBLY gives auto drivers ***3-WAY ADVANTAGE***

BETTER OIL ECONOMY

BETTER ENGINE PROTECTION

LONGER ENGINE LIFE

Oil rings do a very demanding job in an automobile engine. They control the amount of lubricant allowed to pass up to the compression rings and cylinder walls. In modern cars, with higher compression ratios, the tension of the oil ring expanders has had to be increased—and that's where Allegheny Type 201 stainless offers advantages.

Engine operating temperatures have virtually no effect on this new stainless alloy. It maintains constant tension whether the engine is hot or cold, permitting most efficient design for maximum flow of lubricant when friction is greatest, and less flow when the engine is warmed up and requires less. Formerly, carbon steel expander rings suffered a tension drop when heated to engine operating temperature. Then under heat they took a permanent set, which caused the loss of "cold tension." Allegheny 201 also has ended the problem of expander breakage due to the corrosive action of engine deposits.

This success story is just one of many being written with the new 200-series of low-nickel Allegheny Stainless Steels. Fabricating methods are virtually the same as with the higher-nickel 300-series, but you'll find some advantage in cost, and much greater availability in times of nickel shortage. • If these new steels seem to fit into your manufacturing or service picture, give us a call. *Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.* WSW 6528

WRITE for a copy of our "Technical Horizons" bulletin on the Allegheny 200-Series stainless steels.
ADDRESS DEPT: MM-93

Make it BETTER—and LONGER LASTING—with

Allegheny Stainless

AL ALLEGHENY LUDLUM ®

Warehouse stocks carried by all Ryerson steel plants

For more information, turn to Reader Service card, circle No. 469

A

QUARTER MILLION

"STEPS"

IN THE

RIGHT

DIRECTION . .

Today's Modern Miner does BETTER with UNITCASTINGS!

Real proof of the continuous high quality of Unitcastings is the fact that more than 99 percent of the total production of 250,000 treads has been accepted!

Continual operation in underground grit and dust subjects mining machinery treads to extreme abuse. Replacement is difficult and expensive, particularly on this section of the equipment, and parts must be made to last!

For over a decade, the abrasion-resistance quality of Unitcast's T-Loy 34 has answered this tread problem—as well as many other special parts for the same equipment.

Take a step in the right direction, too—*you'll do better with Unitcastings!* They're Engineered!

UNITCAST CORPORATION • Toledo 9, Ohio
In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

Unitcast

SPECIFICATION
STEEL
CASTINGS

For more information, turn to Reader Service card, circle No. 509

efficient of thermal expansion to cope with the expansion characteristics of the materials involved. Accordingly, a series of tests were conducted recently by S. S. Stivala and V. L. Denniger, of the Dept. of Chemistry, Stevens Institute of Technology, to find a material that would successfully bond unlike materials in a vacuum system operating at high temperatures.

The researchers used an epoxy cement consisting of 100 parts of liquid epoxy resin and 10 parts of triethylene tetramine. These were thoroughly mixed and allowed to partially polymerize at room temperature before application.

How cement performs

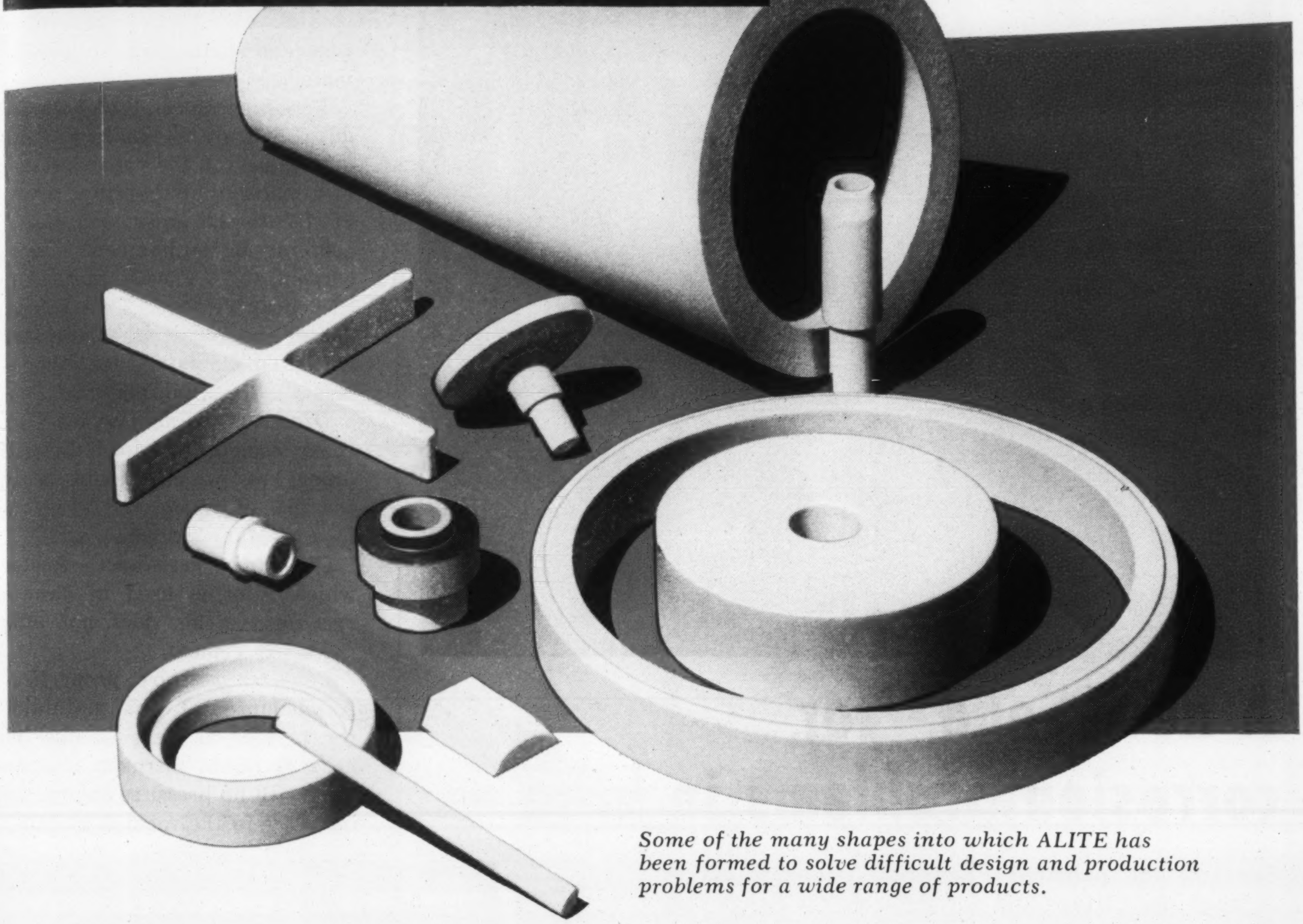
Mechanical strength—Although the actual bond strength of the resin was not determined, the resin, when cured for optimum strength, can withstand approximately 8000 psi in pure tension and 18,000 psi in compression at room temperature; at elevated temperatures its tension and compression are slightly less. The bond between glass and brass did not break down or separate at temperatures as high as 285 F. The epoxy resin bond showed no sign of brittleness, cracking or separation after successive applications of heat because it partially softened and flowed to compensate for expansions of the unlike materials. As a cement, the epoxy resin could be expected to withstand 2000 to 5000 psi at room temperature, depending on test conditions, methods of prepara-

VAPOR PRESSURES OF VACUUM CEMENTS[a]

Epoxy Resin	1.7
Beeswax	5.5
Hard Wax	15.0
Lacquer[b]	2.0
Stopcock Grease	7.0

[a] Microamperes ion current per milliampere electron current.
[b] Baked 4 hr at 390 F.

Is ALITE your answer to a tough design problem?



Some of the many shapes into which ALITE has been formed to solve difficult design and production problems for a wide range of products.

ALITE—the high-alumina ceramic developed by U. S. Stoneware—has superior properties which make it ideal for many highly critical applications. And it could well be that Alite is that "special material" you've been seeking to meet a particularly difficult design requirement.

Among the outstanding characteristics of Alite are its extreme hardness, high mechanical strength, vacuum tightness, zero water absorption, excellent resistance to abrasion, corrosion and nuclear radiation. The high temperature stability of Alite enables it to retain these properties at elevated temperatures (1300°C. to 1600°C. range). We can form Alite to virtually any shape, finish it to precision tolerances, metalize and braze it to metal components to produce high strength, hermetic Alite-to-metal seals. Pump pistons, sleeves, slide valves, seals, bearings and bushings are just a few possible mechanical applications for this versatile material. Alite's low dielectric loss characteristics are utilized in many electronic applications.

If your specifications call for a material with any of the properties Alite possesses, it may pay you to have our ceramics specialists study your requirements. Send us your drawings for our recommendations or quotation.

For detailed information on how Alite can meet your design needs, write for Bulletins A-7R and A-20 today.

ALITE
Ceramic to Metal Seals

69F

ALITE DIVISION **U. S. STONEWARE**
AKRON 9, OHIO

For more information, turn to Reader Service card, circle No. 417

A new "end" for corrosion problems in hose

See how the patented Fluoroflex®-T tube is carried through the fittings and formed over the flange face. Here is complete protection against corrosion because fluids cannot possibly come in contact with metal.

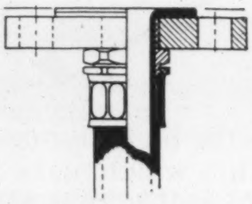
This is the first time chemically inert jacketed fittings have been combined with chemically inert hose in a *continuous* integral assembly.

Fluoroflex-T flanged hose assemblies eliminate the need for special consideration of the type of metal used in the fittings—either for anti-corrosion or contamination needs. As a result of the continuous smooth bore construction, cleaning problems and entrapment of materials are eliminated for all practical purposes.

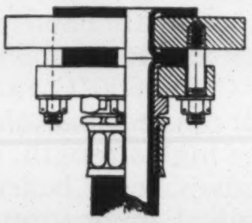
This hose handles active chemicals, solvents, gases and the most corrosive compounds. It is also applicable where vibration is a problem. It is non-aging . . . lasts indefinitely even at 500°F.

Write for data.

® Fluoroflex-T is a Resistoflex trademark, reg., U.S. off.
® Teflon is a DuPont trademark.



See how Fluoroflex-T tube is carried through fitting and across face of flange.



For frequent disconnects, a modified construction is available using a secondary Fluoroflex-T jacketed flange. This is replaceable, spares the major assembly from seal-damage.

Originators of high temperature fluorocarbon hose assemblies

Resistoflex
CORPORATION
Roseland, New Jersey • Western Plant: Burbank, Calif. • Southwestern Plant: Dallas, Tex.

For more information, turn to Reader Service card, circle No. 543

tion, and surface condition of the materials to be bonded.

Vapor pressure—Although it is quite difficult to obtain an absolute value for the vapor pressure of a material of this type, a value of 1.7 to 1.8 microamperes ion current per milliampere electron current at 75 F was obtained for the epoxy cement. This value is one of the lowest when compared with values obtained for other cements and sealing materials.

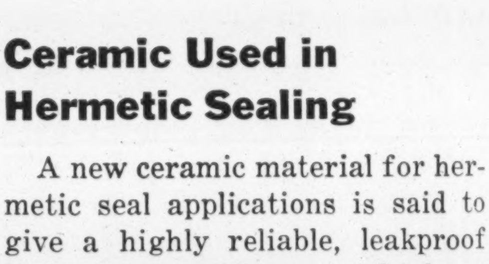
Dielectric properties—The epoxy cement has good dielectric properties, which should permit the use of wires and electrodes in a vacuum system.

Chemical resistance—Acetone which is often used in cleaning vacuum systems does not affect the epoxy cement.

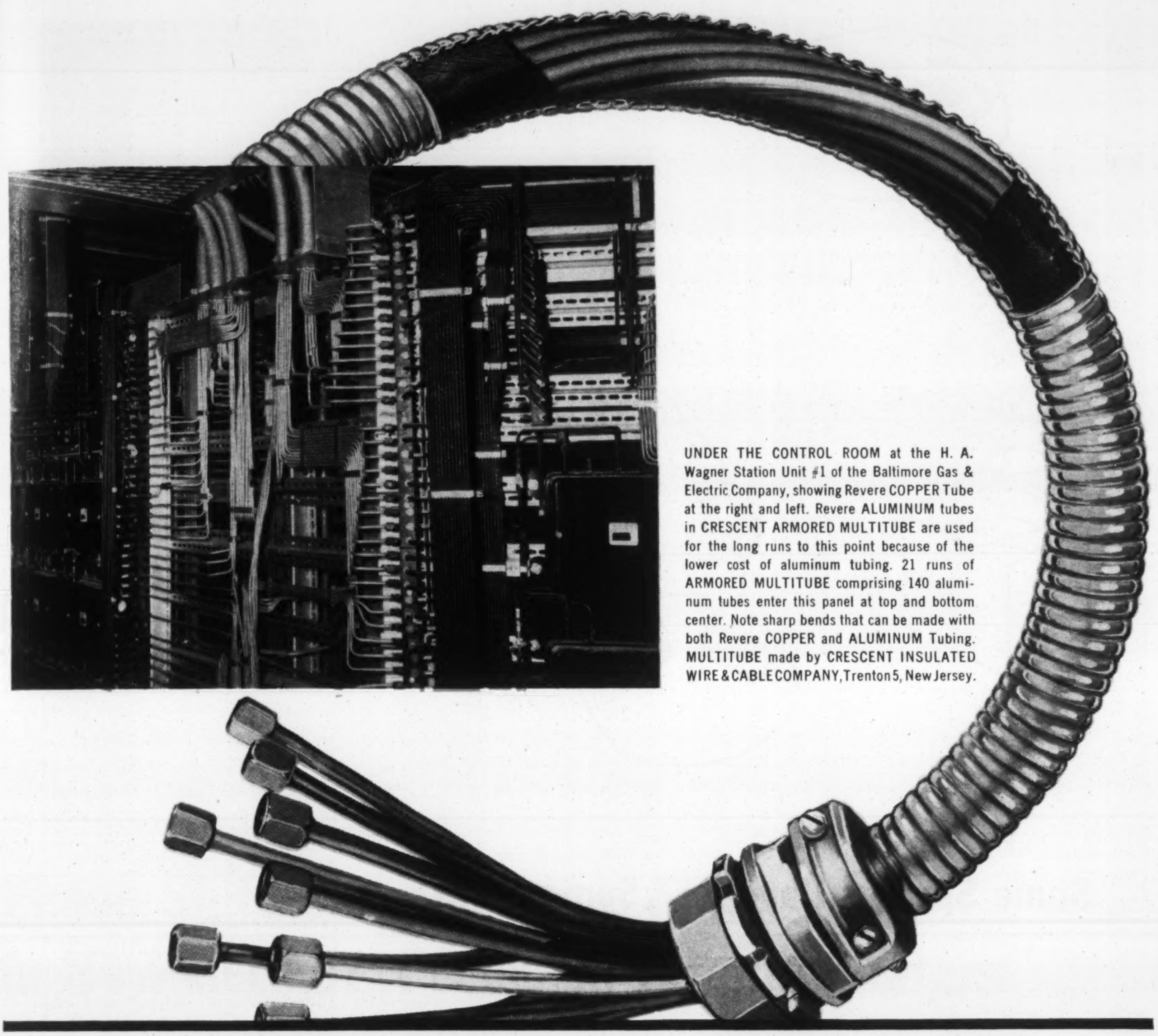
Low temperature properties—A vacuum seal was maintained for periods as long as one half hour at liquid nitrogen temperature with no pressure change taking place in the vacuum system.

Ceramic Used in Hermetic Sealing

A new ceramic material for hermetic seal applications is said to give a highly reliable, leakproof seal at temperatures as high as 700 F. Available from Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif., and known as Ceramicite,



Hermetic seals *made of new ceramic material.*



UNDER THE CONTROL ROOM at the H. A. Wagner Station Unit #1 of the Baltimore Gas & Electric Company, showing Revere COPPER Tube at the right and left. Revere ALUMINUM tubes in CRESCENT ARMORED MULTITUBE are used for the long runs to this point because of the lower cost of aluminum tubing. 21 runs of ARMORED MULTITUBE comprising 140 aluminum tubes enter this panel at top and bottom center. Note sharp bends that can be made with both Revere COPPER and ALUMINUM Tubing. MULTITUBE made by CRESCENT INSULATED WIRE & CABLE COMPANY, Trenton 5, New Jersey.

CRESCENT relies on REVERE

for dependable performance of its instrumentation and control tubing

REPORTS, "NOT ONE FAILURE."

The dependable performance of Revere Copper Tube in Crescent Armored Multitube*, ever since its inception, has led the CRESCENT INSULATED WIRE & CABLE COMPANY to fill its aluminum tube needs with Revere also.

In fact, Crescent, since it first started using Revere Copper Tube in 1953, reports not a single failure. And that's mighty important in instrumentation and control tubing service where utilities, chemical processing, petroleum, paper and similar industries can't afford the luxury of process failures.

Crescent Multitube, using either Revere Copper or Aluminum Tube, or both in combination, offers a completely protected installation for permanence, lower original installation cost, lower maintenance and a saving of time, space and money.

Crescent Armored Multitube consists of a group of Revere Copper or Aluminum Tubes, twisted together in cable form, protected by a flexible interlocked galvanized steel armor. Constructions are available employing plastic sheaths in combination with the armor for corrosive locations. Section of cabled tube pictured shows how Copper or Aluminum Tubes are encased inside the Armored Multitube. As many as 37 tubes of ¼″ OD can be cabled in lengths up to 1,000 ft.

For details on Multitube write Crescent and for uniform quality copper and aluminum tube, speedily delivered, see the nearest Revere Sales Office.

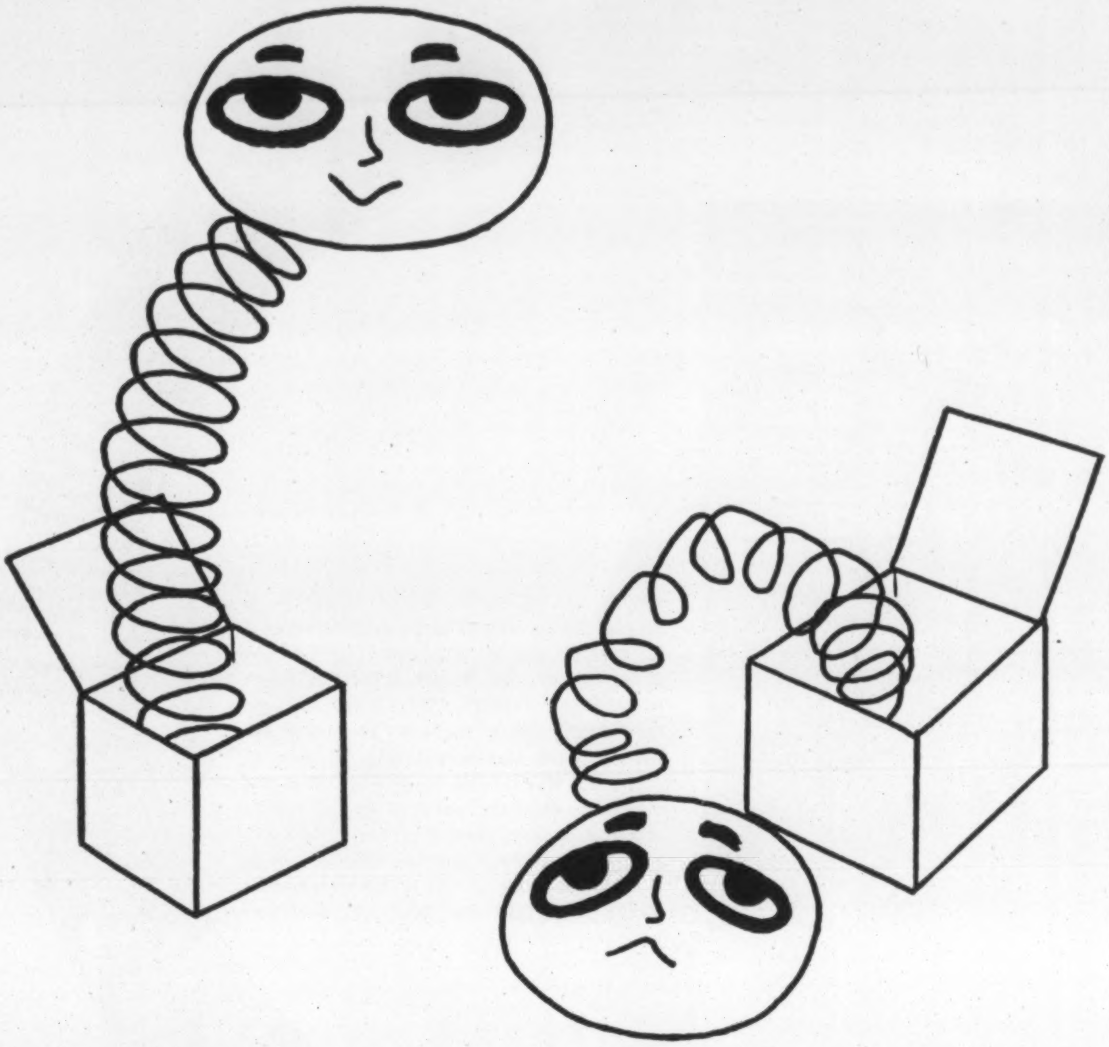
*Reg. Trademark

REVERE COPPER AND BRASS INCORPORATED
Founded by Paul Revere in 1801
230 Park Avenue, New York 17, N. Y.

Mills: Rome, N. Y.; Baltimore, Md.; Chicago, Clinton and Joliet, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Brooklyn, N. Y.; Newport, Ark.; Ft. Calhoun, Neb. Sales Offices in Principal Cities, Distributors Everywhere.

COPPER ★ BRASS
18 01
REVERE
ALUMINUM

For more information, turn to Reader Service card, circle No. 529



Some Springs Have It...Some Don't

The difference in spring performance is most often due to the wire or strip used... and there's more to a spring material than just the "bounce". How about other requirements, such as corrosion resistance, high temperature properties, fatigue resistance and low temperature toughness.

When your springs need any of these properties your best bet is one of our alloy spring materials.

Riverside-Alloy Metal Division can supply you with spring wire and strip in stainless steels, nickel alloys, phosphor bronze and beryllium copper.

Learn more about our spring materials. Write to
Riverside-Alloy Metal Division,
H. K. Porter Company, Inc., Riverside, N. J.

Send today for our free handbooks

ALLOY METAL WIRE
Prospect Park, Pa.

RIVERSIDE METAL
Riverside, N.J.

PRENTISS WIRE MILLS
Holyoke, Mass.

H. K. PORTER COMPANY, INC.
RIVERSIDE-ALLOY METAL DIVISION

For more information, turn to Reader Service card, circle No. 584

DESIGN HANDBOOK of Stainless Steel
Riverside Alloys

the material is said to bond physically to most stainless steels.

The ceramic may be used to hermetically seal relay, transformer and transistor bases; diode closures; and other electronic components. It is available as preformed pieces and as completed seal components.

Synthetic Rubber Used to Make Truck Tires

Butyl rubber military truck tires, the first such tires made wholly from a mass produced synthetic rubber, have successfully passed grueling Army Ordnance cross-country and highway road tests. Ordnance engineers say the tires, which use no natural rubber, "represent the closest approach yet to making this country free of dependence on natural rubber since the tires are made from a synthetic rubber available in commercial quantities."

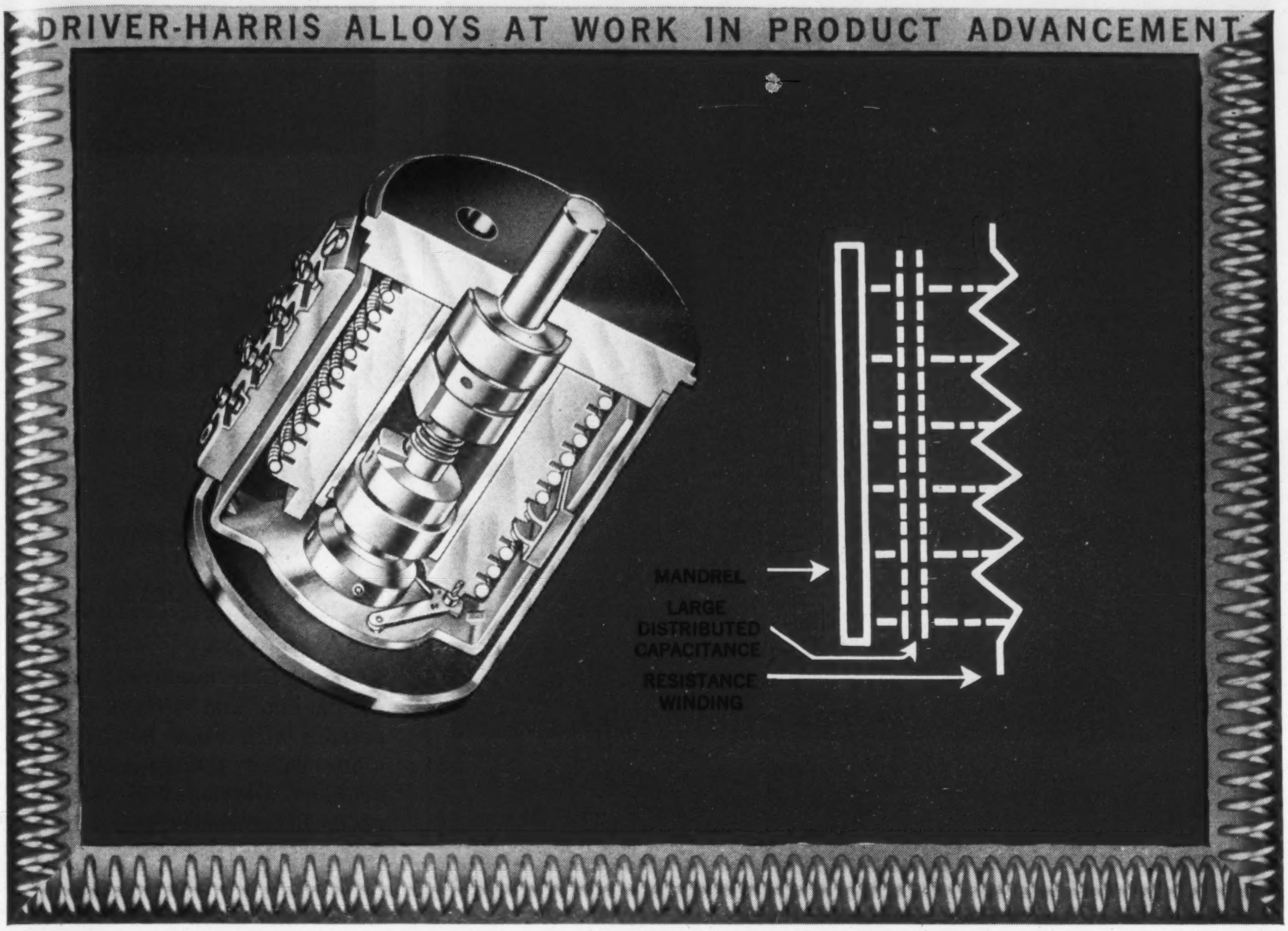
Improved modifying agents added to the rubber are said to lower heat generated in the tire. In addition, the butyl tires are said to have excellent resistance to ozone cracking, deterioration and chipping.

The all-synthetic rubber tires can be made on conventional tire vulcanizing equipment. This was made possible with the development of a butyl latex dip that permits the bonding of butyl rubber with the tire cord.

Actual tire development was carried out by the Pennsylvania Tire Co. Div., Mansfield Tire and Rubber Co., in cooperation with Esso Research and Engineering Co.

New Technique Bonds Soft Metals to Silicon

A firm bond between soft metals, such as gold, silver and aluminum, and single crystal


DRIVER-HARRIS ALLOYS AT WORK IN PRODUCT ADVANCEMENT
MANDREL
LARGE DISTRIBUTED CAPACITANCE
RESISTANCE WINDING

Phase Shift Compensation Eliminated In New HELIPOT® Precision Potentiometers

SPECIAL D-H ALLOYS MAKE AIR-CORE WINDINGS PRACTICAL!

Helipot's purpose in designing its new, air-core wound series 7700 Potentiometers was to make possible operation at higher frequencies with 0° phase shift—thereby eliminating compensation circuitry.

In nearly all multi-turn potentiometers, resistance wire is wound on an insulated copper-wire mandrel. This type of mandrel is used because it has uniform diameter, good heat conductivity and high thermal capacity. However, a disadvantage of such construction is the relatively large distributed capacitance between the resistance winding and the mandrel. When such a potentiometer is used as an AC voltage divider, the output generally differs in phase and magnitude from the desired output. This interferes with the effective use of high accuracy potentiometers unless compensation is applied somewhere in the circuit.

Helipot engineers desired to eliminate these problems by eliminating the copper-wire mandrel. But the elimination of the mandrel also eliminated the support for the winding. Needed, therefore, was a type of wire that would make a self-supporting air-core winding.

At Helipot's request, Driver-Harris went to work with these specifications: The wire must be of dependable uniform hardness so that in stretching it, equal spacing between turns is obtained, free of creep. This is essential to linearity. The wire also must be of unvarying diameter for uniform resistance. And its surface must be extremely clean—free of oxide coating to minimize contact "noise".

Driver-Harris produced the wire—a special hard-drawn form of Karma* and Nichrome* V. And Helipot produced its new 10-turn series 7700 potentiometers in a resistance range from 200 to 5000 ohms. With this radically new air-core winding, linearity approaches the resolution of the unit without resort to padding or shunting. And phase shift in AC circuitry is reduced to less than 0.1°.

Since 1899, Driver-Harris has produced 132 special-purpose alloys in just this fashion—in answer to a particular problem and extraordinary specifications. If your own engineering and product development plans currently hinge upon a special alloy—why not bring your problem to Driver-Harris. Your inquiry is invited.

*T.M. REG. U.S. PAT. OFF.

Driver-Harris* Company

HARRISON, NEW JERSEY • BRANCHES: Chicago, Detroit, Cleveland, Louisville
Distributor: ANGUS-CAMPBELL, INC., Los Angeles, San Francisco • In Canada: The B. GREENING WIRE COMPANY, Ltd., Hamilton, Ontario

MAKERS OF THE MOST COMPLETE LINE OF ALLOYS FOR THE ELECTRICAL, ELECTRONIC, AND HEAT-TREATING INDUSTRIES

For more information, turn to Reader Service card, circle No. 506

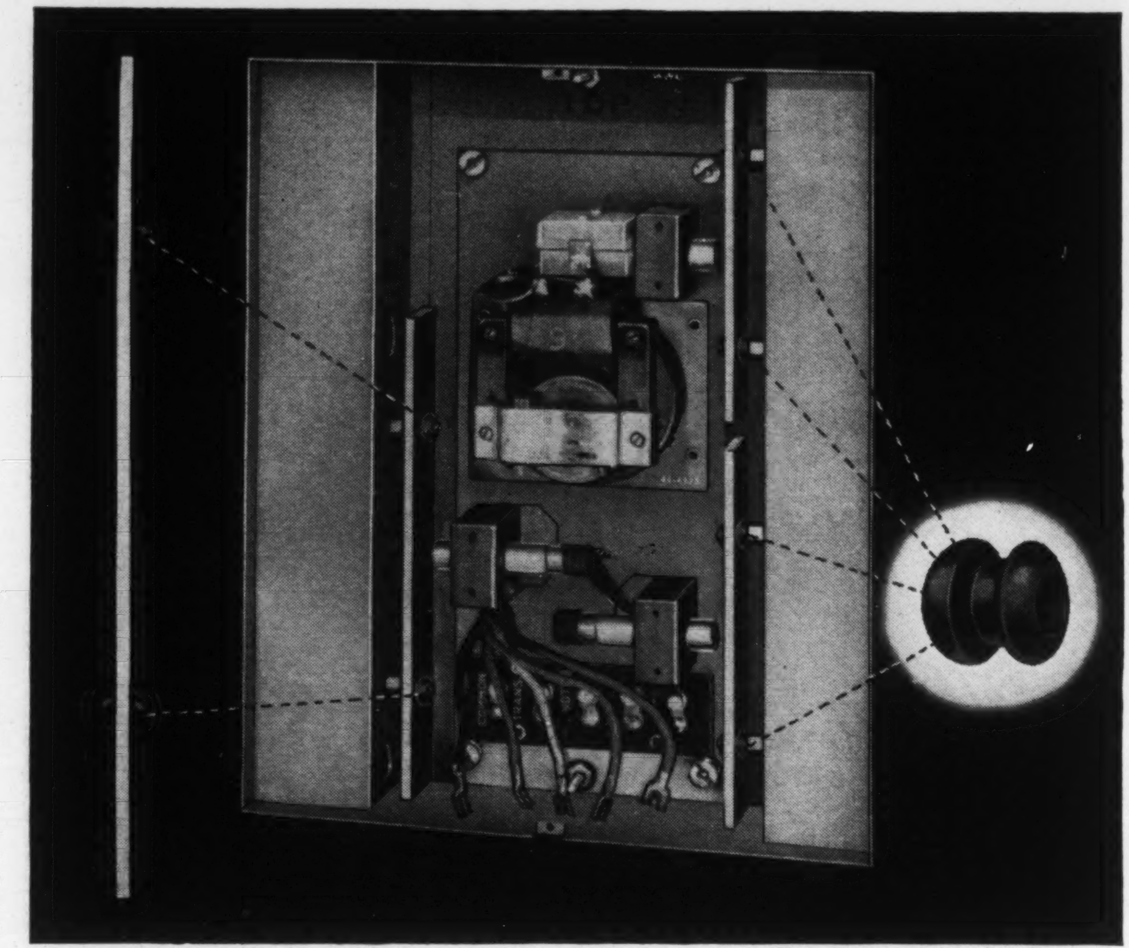


Photo courtesy Nutone, Inc., Cincinnati

Engineers Develop New Use for Rubber

Rubber, normally used to *reduce* vibration, now can be made to *increase* vibration

Here rubber grommets serve as mountings for the tone bars in Nutone Door Chimes. To obtain maximum tone quality and resonance required of these musical chimes, the grommets must vibrate compatibly with the tone bars . . . a truly *unusual assignment* for rubber.

Only by skillful compounding can rubber be diverted from its normal dampening characteristic and be given this vibrant quality. The slightest deadening effect would destroy the rich tones and kill the tone hang.

The successful development of this lively, age-resistant rubber stock typifies the complete engineering and laboratory—as well as manufacturing—skill available at Continental. Whenever you need "engineered rubber parts" — molded or extruded, natural or synthetic—call Continental, Specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
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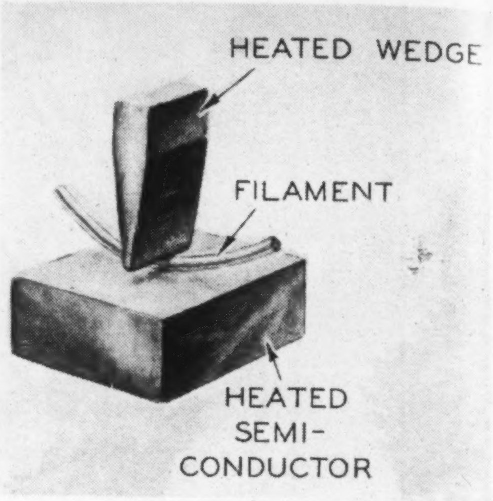


semiconductor materials, such as germanium and silicon, is now possible with a new bonding technique called thermo-compression bonding. Developed at Bell Telephone Laboratories, the technique is used in attaching soft metal leads to semiconductor devices.

Basically, the technique consists of using a heated element such as a wedge, flat or point to press leads against a heated semiconductor. Pressures of a few thousand pounds per square inch and temperatures well below the melting point of both the lead metal and the semiconductor are used to instantly bond the lead to the semiconductor. The technique requires no chemical flux and can be used in mass producing electronic parts.

Effect of Sea Water on Steel and Titanium

The Sea Horse Institute, which meets annually at the Harbor Island, N. C., marine testing facilities of International Nickel Co. to discuss developments in corrosion testing, has come up with several interesting notes concerning corrosion of steel and titanium.

A generalization that appears to be valid after years of testing is that corrosion of mild steel in pure sea water amounts to about 3-5 mils per year, regardless of location. In the tropics, although rate

For more information, circle No. 592 ➤

of attack is higher, marine growth is stimulated and growth prevents oxygen from reaching the steel surface. In northern latitudes, marine growth is retarded, but so is the rate of attack as a result of the low temperatures.

Titanium apparently suffers no damage in sea water, regardless of exposure. In atmospheric exposure at the sea coast, an extremely thin film develops on titanium after five years exposure. By contrast, Hastelloy C is still mirror bright after 16 years. In general, titanium and stainless steel are about equal in resistance to attack.

According to the Institute, corrosion fatigue of steel in sea water can be prevented by cathodic protection, as shown by the following data based on tests conducted on steel wire specimens (106 cycles, 25,000 psi tensile strength):

Air	76,000 psi
Sea water	12,500 psi
Sea water with cathodic protection	68,000 psi

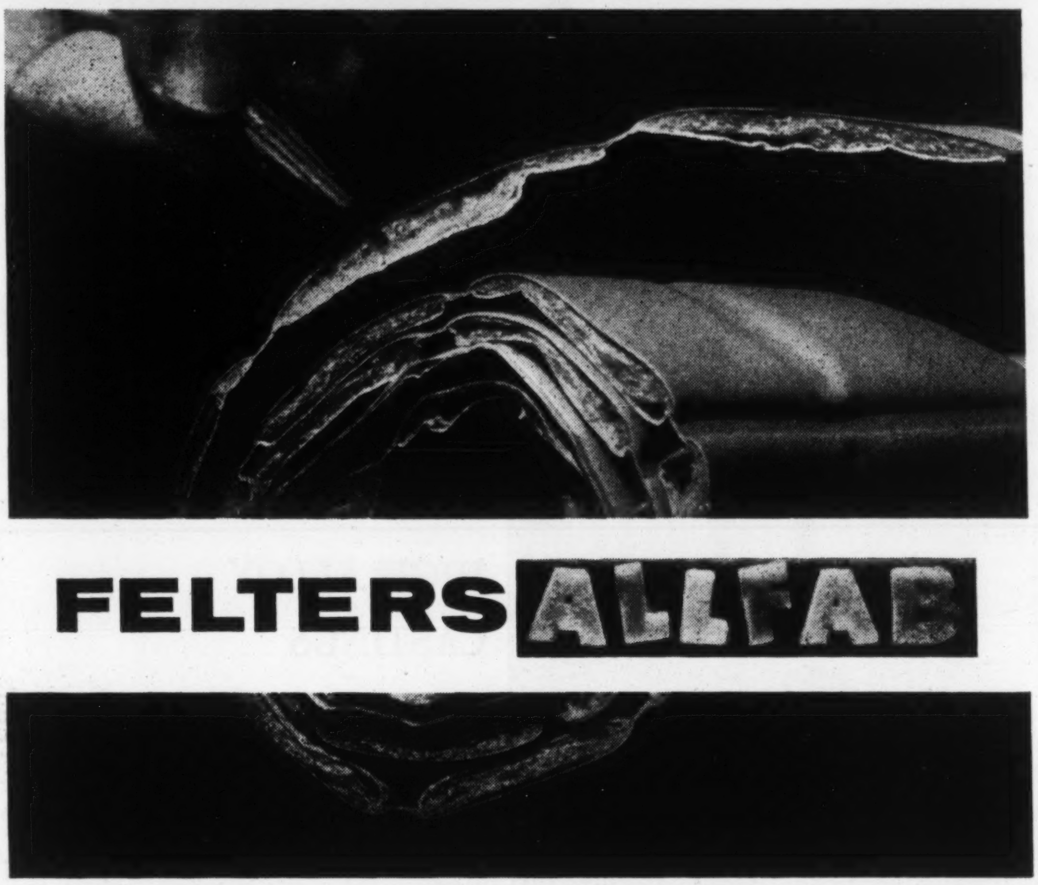
Ceramic Fiber Tapes Warn of Leaking Pipes

High temperature insulating fabrics, available in various widths and thicknesses, have been introduced by Russell Mfg. Co., South Farms, Middletown, Conn., for service up to 1500 F. Made of ceramic fibers, the fabrics can be treated with silicone rubbers and epoxy and phenolic resins and molded into various shapes.

In addition to insulation, the fabrics can be used as instrumentation tapes for both insulation and leak detection. When wrapped around pipes carrying metallic or radioactive fluids, the tape, consisting of two stranded Chromel wires covered with reinforced ceramic fibers, acts as an insulation and in the event of a leak causes an alarm-sounding short circuit. The producer says the tape operates at 1500 F for 1500 hr.

NOW!

Low-Cost Backing Material Cuts Upholstery and Backing Costs



AllFab is a revolutionary fabric of cardable fibers like wool, rayon, cotton, dynel, nylon and dacron combined with a resin binder.

This thermoplastic binder has two big advantages: (1) AllFab will hold and give dimension to any embossed pattern, and (2) it is possible to electronic "stitch" or heat seal, eliminating sewing.

Result: A felt-like fabric with a tremendous range of fiber combinations, using selections of diameters, lengths and gravities to meet your own specifications.

Find out about this brand new all-purpose, non-woven fabric NOW. Put its special properties to use as a low-cost filler and backing material. Call sales office nearest you, or send coupon below.

Properties

Can use almost any cardable fiber or combination • Vary resin content from 15-45% • Thickness from 1/16" to 1", specialties to 2" • Weight from 4 oz. to 16 oz. and up • Width from 16" to 80" but 72" preferred • Color within mix limits, natural shades

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Small

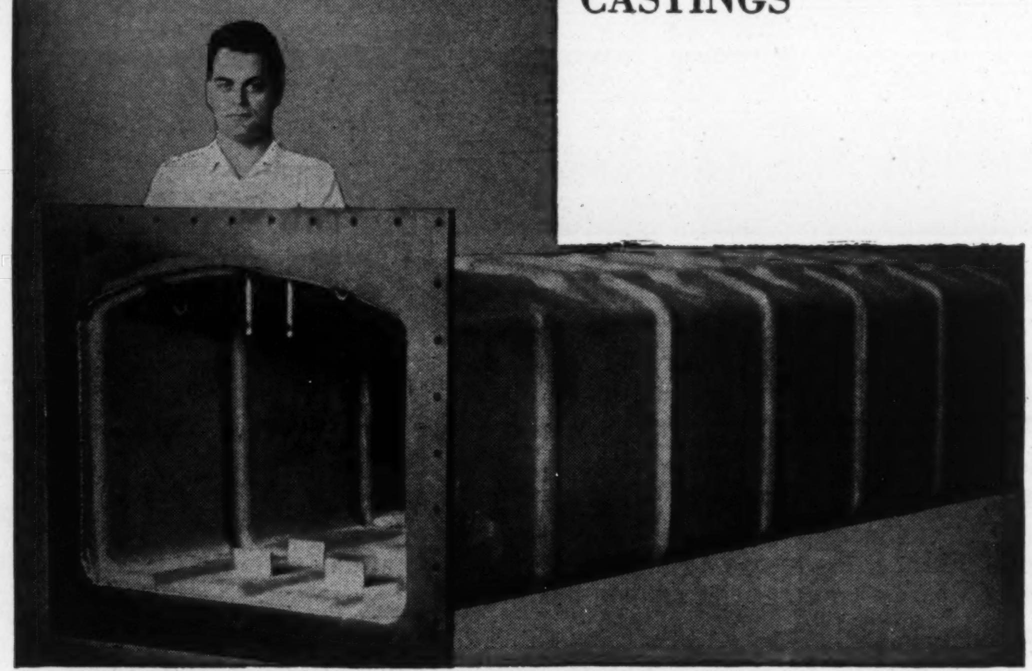
HIGH ALLOY
CASTINGS

Carburizing Fixture for Ball Bearings 1½" diameter—Analysis 35% Ni — 15% Cr

DURALOY

Large

HIGH ALLOY
CASTINGS



Muffle for Continuous Strip Annealing 12' 6" long — Analysis 38% Ni — 18% Cr.

LARGE or small DURALOY, can do it! These are just typical examples of the work moving through our foundry. Some of these castings are designed for heat resistance, some for corrosion resistance, some for abrasion resistance; all are cast by experienced foundrymen. All are carefully tested in our up-to-date laboratory.

If you have a high alloy casting problem . . . LARGE or small, we can help you. For more information, send for Bulletin No. 3150-G.

The DURALOY Company
OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
ATLANTA OFFICE: 76—4th Street, N.W.
CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

For more information, turn to Reader Service card, circle No. 383

Fuel tanks—continued from p 12

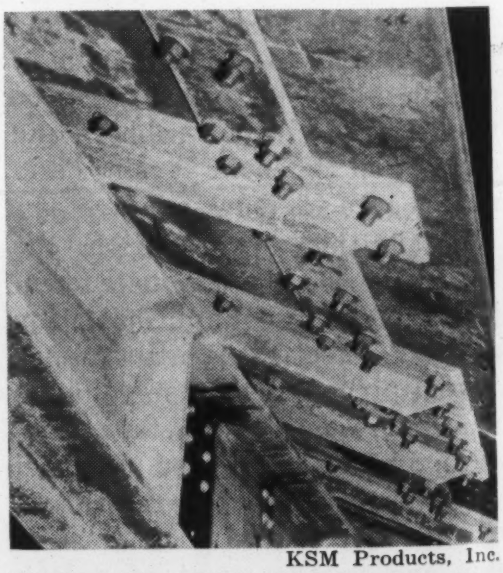
tanks are given pressure and vibration tests.

In addition to preventing jettisoned fuel tanks from being salvaged (the reinforced plastics tanks shatter when dropped from an airplane), the plastics wing tanks offer the following advantages over aluminum: they are easier to produce, less costly and comparable in weight.

Stud Welding Technique Extends Life by 50%

Use of stud welding has resulted in extended lifetime, better performance and reduced cost for the steel floor plates used in U.S. Steel Corp.'s coke quenching cars.

The coke quenching cars, used about 250 times in a 24-hr period, are loaded with 12½ tons of flaming coke and then sped to a quenching tower where cascades of water bring the temperature down from 2100 F. Previously, the abrasive action of the tons of coke smashing against the floor surface, the corrosive action created during the quenching process, and the thermal shock effect of the high temperature coke suddenly being cooled, caused severe



KSM Products, Inc.

***Underside of car** showing location of studs through supporting members. Studs are installed by using a simple template.*

OVER-DESIGNING?

If you are designing bronze parts for mass production, there is a good chance that you are specifying a more costly alloy than you need.

ASARCO's patented continuous-casting process produces alloys according to SAE, ASTM and Government specifications. But their performance is entirely unlike that of similar alloys cast in sand or permanent molds. Relatively low-cost alloys cast by the ASARCO process perform like more expensive alloys cast by other methods.

For example, compare Continuous-Cast SAE 660 (ASARCON 773) with more expensive sand-cast alloys:

	Typical Yield Strength	Typical Impact Strength	Brinell Hardness
ASARCON 773	27,000 psi	12.5 ft.-lbs.	72
Sand-Cast SAE 62	20,000 psi	8.7 ft.-lbs.	65
Sand-Cast SAE 64	17,000 psi	8.2 ft.-lbs.	62

Unless you've checked to see whether the unique ASARCO bronzes can give you what you need, there's a possibility that you're over-designing. You may even be able to replace aluminum and manganese bronzes with low-cost ASARCON Continuous-Cast bronzes under certain conditions. Over-designing can be expensive in mass production, even if you are spending only a penny or two extra per pound of bronze.

ASARCON 773 (SAE 660) is readily available from stock in a wide range of sizes. An added bonus is the fact that ASARCON 773 is exceptionally free-machining. Rods, tubes, and numerous "extruded" shapes up to 9 inches in diameter are cast to order by ASARCO in more than 20 alloys.

We'll be happy to send you a free booklet describing the process and the product.

Continuous-Cast Products Department

AMERICAN SMELTING AND REFINING COMPANY

Perth Amboy Plant, Barber, New Jersey • Whiting, Indiana

WEST COAST SALES AGENT: Kingwell Bros. Ltd., 457 Minna Street, San Francisco IN CANADA: Federated Metals Canada, Ltd., Toronto and Montreal

For more information, turn to Reader Service card, circle No. 523

new . . . booming . . . stainless steels
call for consistent analysis

MANGANESE	99.9% MINIMUM
CARBON	0.004% MAXIMUM
SULPHUR	0.024% MAXIMUM
IRON	0.001% MAXIMUM
HEAVY METALS	0.005% MAXIMUM
PHOSPHORUS	NOT DETECTABLE IN 25 GRAM SAMPLE
SILICON	SPECTROGRAPHIC TRACES ONLY
HYDROGEN	0.015% MAXIMUM

and ELECTROMANGANESE® has it

Stainless steel is on the move. Industry after industry is attracted by its recent strides in transportation equipment, appliances, architectural trim, household and store furnishings. And of all the stainless steels, the most stimulating seem to be the new 200 Series, characterized by high manganese, low nickel, content.

But—high manganese content also means consistent analysis in this critical alloying agent. The percentage of each impurity must be known and consistent in melt after melt. This calls for the purest commercial manganese available . . . Foote electrolytic manganese. Electromanganese, by trade name, consistently provides 99.9% manganese content in the analysis shown above. If you have a hydrogen problem, even this can be reduced to 7.5 ppm maximum in a *Hydrogen-Removed* grade. Nitrided manganese is available in Foote's high-purity Nitrelmang.® But just as important as consistent analysis is economy. And here Foote's alloying agents enable you to get the necessary manganese content in the most efficient way.

The 17 years' experience in manganese alloying available from Foote's Electromanganese Division is an important first step when you decide to really pursue the growing stainless steel market. A letter will bring a Foote engineer to your desk. Or, you can get further information by writing to our Technical Literature Department, Foote Mineral Company, 408 Eighteen West Chelten Building, Philadelphia 44, Pa.

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SALES OFFICE: *Electromanganese Division, Knoxville, Tennessee*
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PLANTS: *Cold River, N. H.; Exton, Pa.; Kings Mountain, N. C.; Knoxville, Tenn.; Sunbright, Va.*

ELECTROLYTIC MANGANESE METAL • WELDING GRADE FERRO ALLOYS • STEEL ADDITIVES • COMMERCIAL MINERALS AND OXIDES • ZIRCONIUM & TITANIUM (IODIDE PROCESS) • LITHIUM METAL, CHEMICALS AND MINERALS • STRONTIUM CHEMICALS

For more information, turn to Reader Service card, circle No. 512

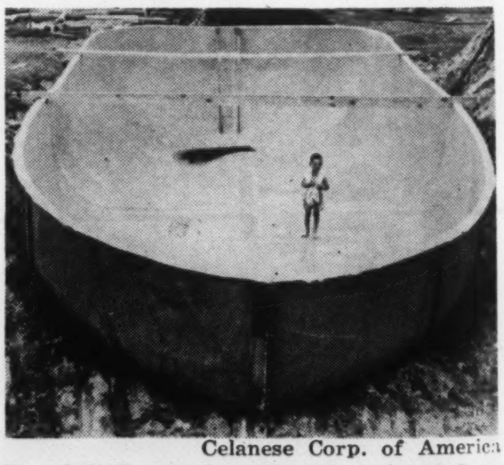
damage to the car's steel floor plates. In fact, the floor plates had to be changed every 15 or 16 weeks.

As a result of the switch from countersunk head bolts to stud welding, three major advantages have been achieved:

1. Since the plates now form an uninterrupted floor surface, leakage to the undercarriage of the car is held to a minimum. The lifetime of the car's chassis is therefore extended.
2. The operating time of the cars before a change of floor plates is required has been increased by about 50%.
3. Shop costs of repairing a car have been cut drastically.

Silicone Rubber Ducts Withstand Heat, Cold

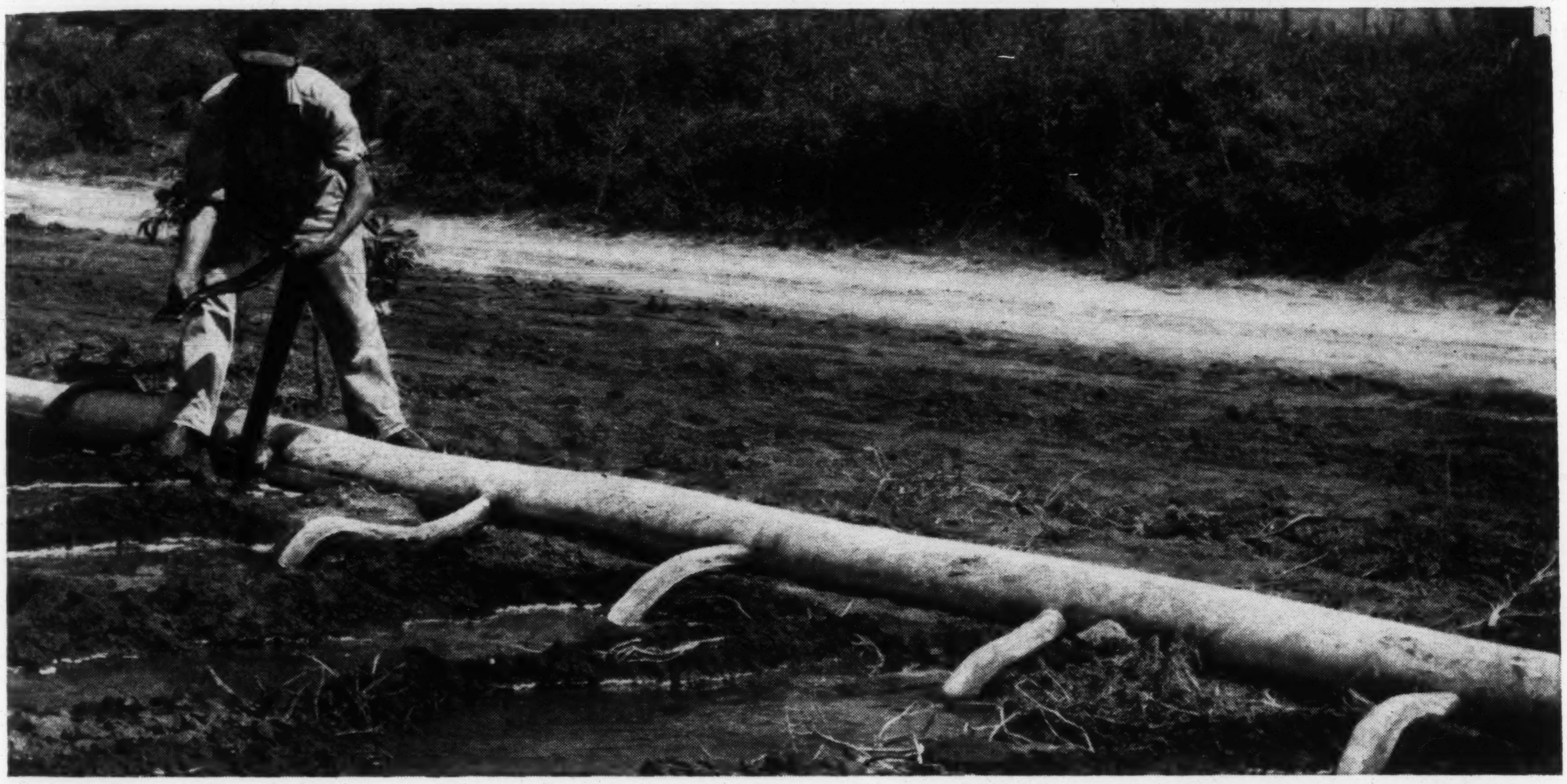
When the new Douglas DC-8 airplane is completed it will have in its construction more silicone rubber than any other aircraft yet produced. Various types and grades of silicone rubber will be used in high temperature ducting



Celanese Corp. of America

Prefabricated plastics pool — Latest in the growing list of plastics swimming pools is the one shown here made of fibrous glass-reinforced polyester resins. Unlike most conventional pools, this model is bolted together at the site and then lowered into the hole.

NOW! IRRIGATION THAT'S TRULY PORTABLE



AND COSTS LESS! THANKS TO ENJAY BUTYL!

Flexible irrigation "pipe" and ditch liners fabricated from Enjay Butyl rubber are helping farmers and growers conserve water by assuring maximum irrigation from available water supplies . . . and at *lower cost!* Combining flexibility with strength and portability, the "pipe" allows irrigation of different areas with the same equipment in a one-man carry operation. Both "pipe" and ditch liners are impervious to weather and highly resistant to soil acids and bacteria. These systems are manufactured by the Carlisle Corp., Carlisle, Pa., and are distributed by Bono Products, Inc., Taft, Texas.

Enjay Butyl may well be able to *cut costs* and *improve the performance* of *your* product! *Low-in-cost* and immediately available, this truly wonder rubber has been put to profitable use in a wide variety of industrial and consumer products. For further information, and for expert technical assistance, contact the Enjay Company.

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Enjay Butyl is the greatest rubber value in the world. It's the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

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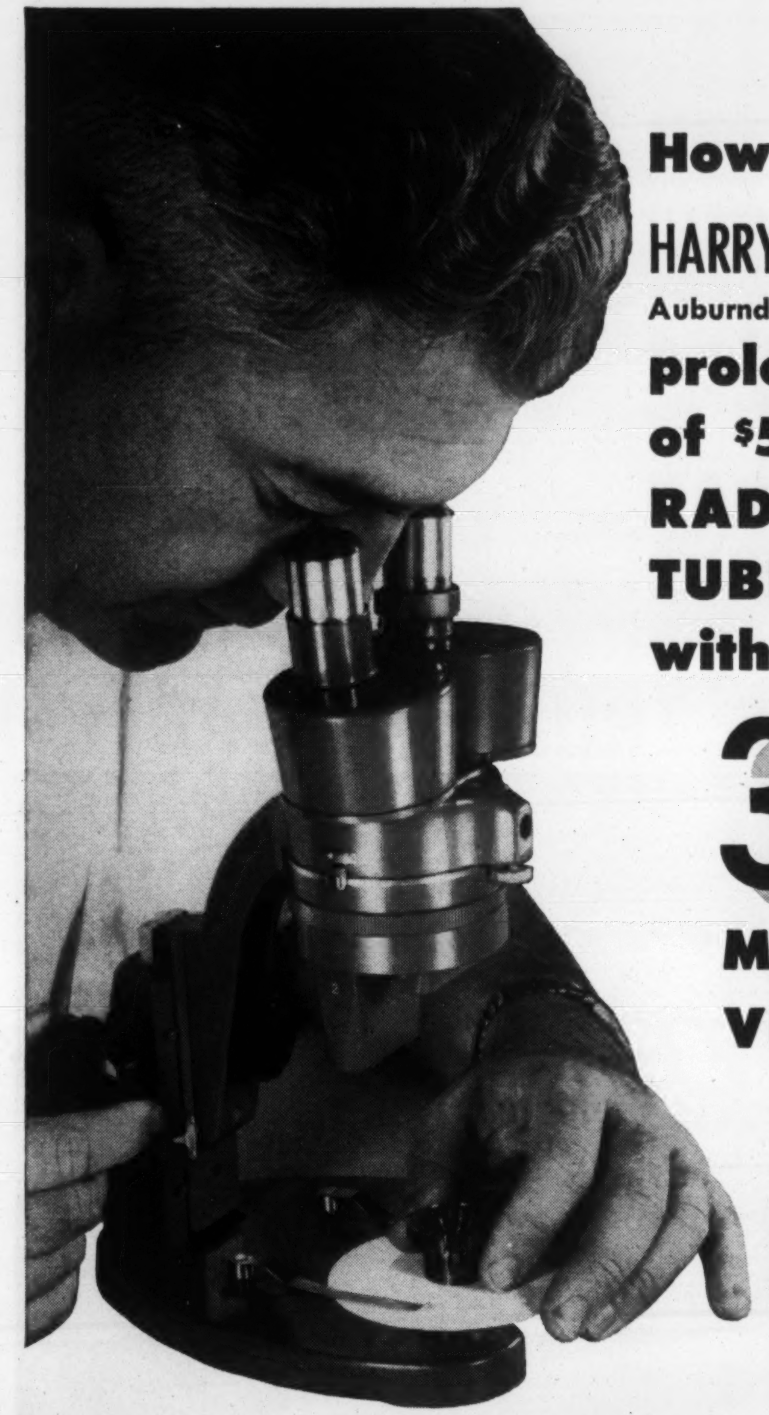


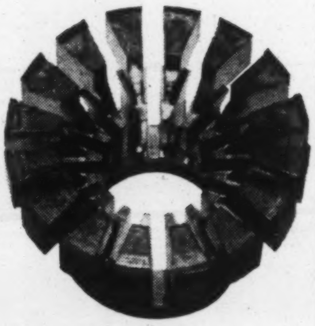
How

HARRY WOLFF Co., Inc.

Auburndale, Massachusetts

prolongs life of $5000 RADAR TUBES with

3-D MICRO-VISION



A tiny burr on this tuning crown will burn off at normal operating temperatures and cause radar tube failure. Precision components like this are made of metals that cost over $100 per pound. The tube costs up to $5000. Obviously, rejects and failures are prohibitively costly.

That's why Harry Wolff Co., Inc., uses Bausch & Lomb Stereomicroscopes to check 368 different edges of each tuning crown. Inspectors see the work right-side-up, clearly magnified in vivid 3-dimensional detail. Burrs are quickly revealed, and easily scraped off.

And that's why Harry Wolff, president, says: "We consider the B&L Wide Field Stereomicroscope as important to us as a precision lathe."

FREE! GET THIS EXCLUSIVE 3-D MICRO-VISION BOOK

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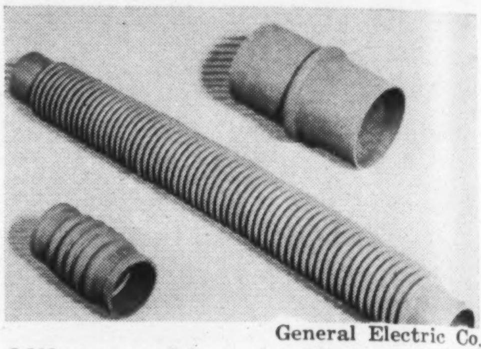
MATERIALS AT WORK



General Electric Co.

***Silicone rubber ducting** and duct connectors used on Douglas airplane.*

for de-icing, defrosting and heating systems, and for window and hatch seals and other airframe enclosures.

Silicone rubber was chosen because of its excellent performance at temperature extremes and because it does not give off toxic fumes or obnoxious odors in high temperature service. In addition, the rubber is lighter than comparable metal parts, is free from metal fatigue, reduces noise levels and is easier to install than rigid materials.

The material is claimed to be capable of withstanding 1000 hr exposure to air ranging from 350 to 700 F at pressures up to 150 psi. At temperatures as low as –100 F, the material is said to retain complete flexibility.

Curtain Wall Panels Need No Finishing

Porcelain enameled steel panels that are complete with exterior and interior finish, insulation, structural independence and means of attachment, are providing the recently completed Miami Beach Federal Building with an efficiently insulated curtain wall.

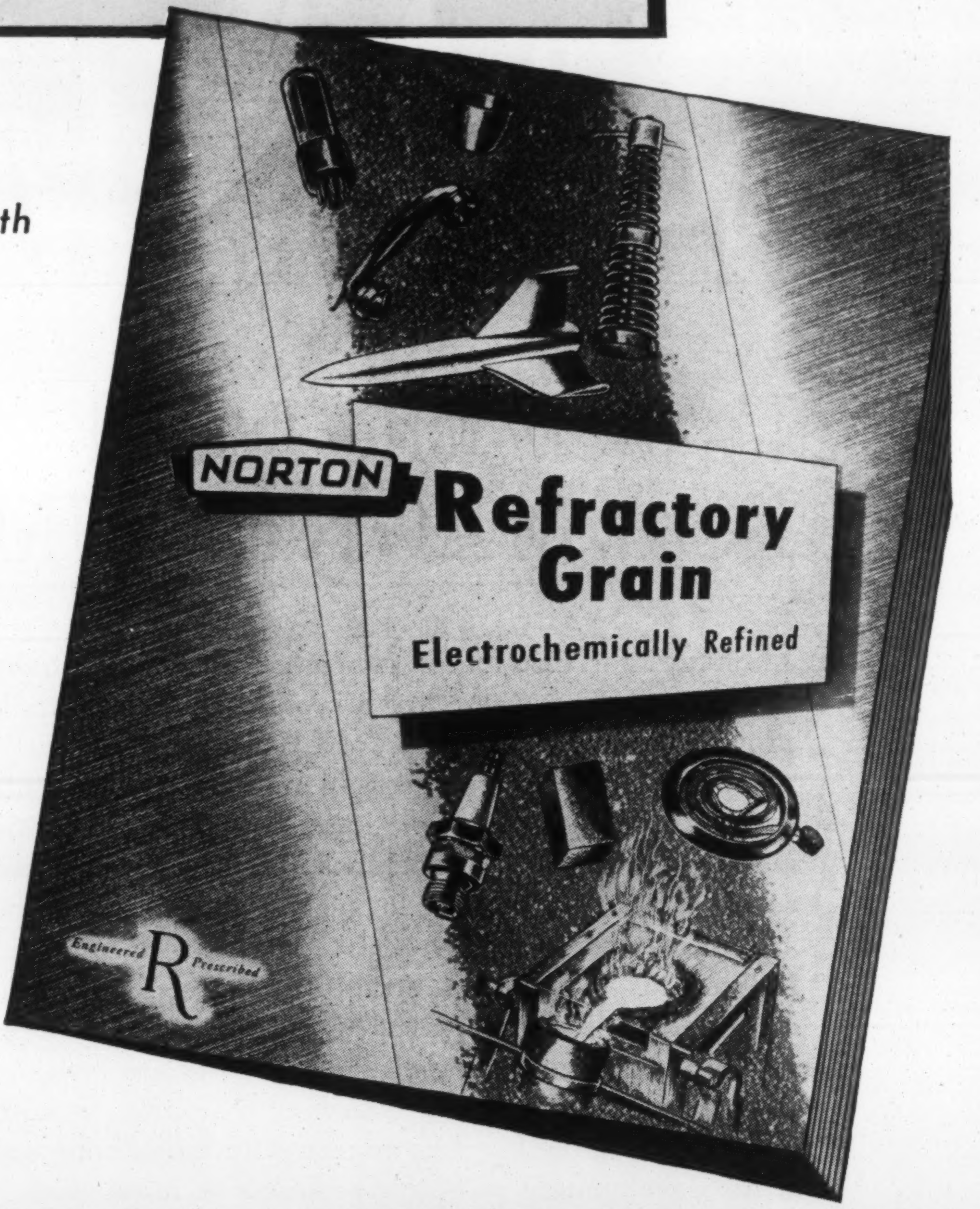
Manufactured by the Trucson Steel Div., Republic Steel Corp., the outside face of the panel is composed of porcelain enamel on 16-gage enameling iron. The inside face is 18-gage carbon steel sheet that has been electrogalvanized, bonderized and finished with two coats of baked enamel. To

You May Profit From This Book

✓ *if you are concerned with processing that involves temperatures ranging upwards to 4000°*

✓ *if your progress in processing depends upon materials of high purity.*

✓ *if it would help you to obtain a modern material with unusual electrical characteristics.*



Here is a valuable reference book that tells you all about the chemical and physical characteristics of such materials as CRYSTOLON* Silicon Carbide, ALUNDUM* Aluminum Oxide, MAGNORITE* Magnesium Oxide, Fused Zirconia and Boron Carbide.

Describing how these electrochemically refined materials react under varying conditions, this book gives you plenty of facts on materials that are helping to solve processing problems.

Get this useful help towards solving your own processing problems. Write today for your free copy of "Norton Refractory Grain." NORTON COMPANY, Refractories Division, 349 New Bond Street, Worcester 6, Mass.

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WEIGHT
MEANS
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That's why design engineers in many fields of manufacture are switching to magnesium. You'll find magnesium in automobiles, office machines, industrial equipment, consumer goods such as luggage, furniture, household appliances . . . *wherever* weight and cost are important. Lightest of the world's structural metals, magnesium can be cast, formed, extruded, drawn or worked into virtually any size or shape! Tooling costs are lower . . . machining, fabrication, processing, handling, assembly costs too! Magline Inc. has worked with many companies in the development of better products at lower cost . . . through the application of magnesium. Put this experience to work for you. Four plants to serve you . . . with complete facilities for cast or fabricated products.

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☐ Die Castings ☐ Sand Castings
☐ Permanent Molds ☐ Fabrications

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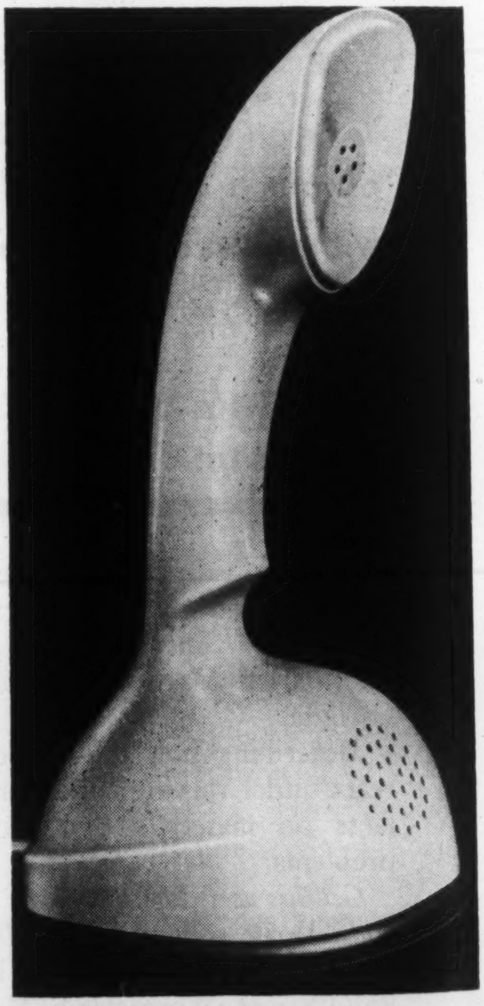
assure a permanent flat surface on the curtain wall panels, the porcelain enamel steel faces were subjected to a load test of 45 lb per sq ft; flatness did not deviate more than ± 1/8 in.

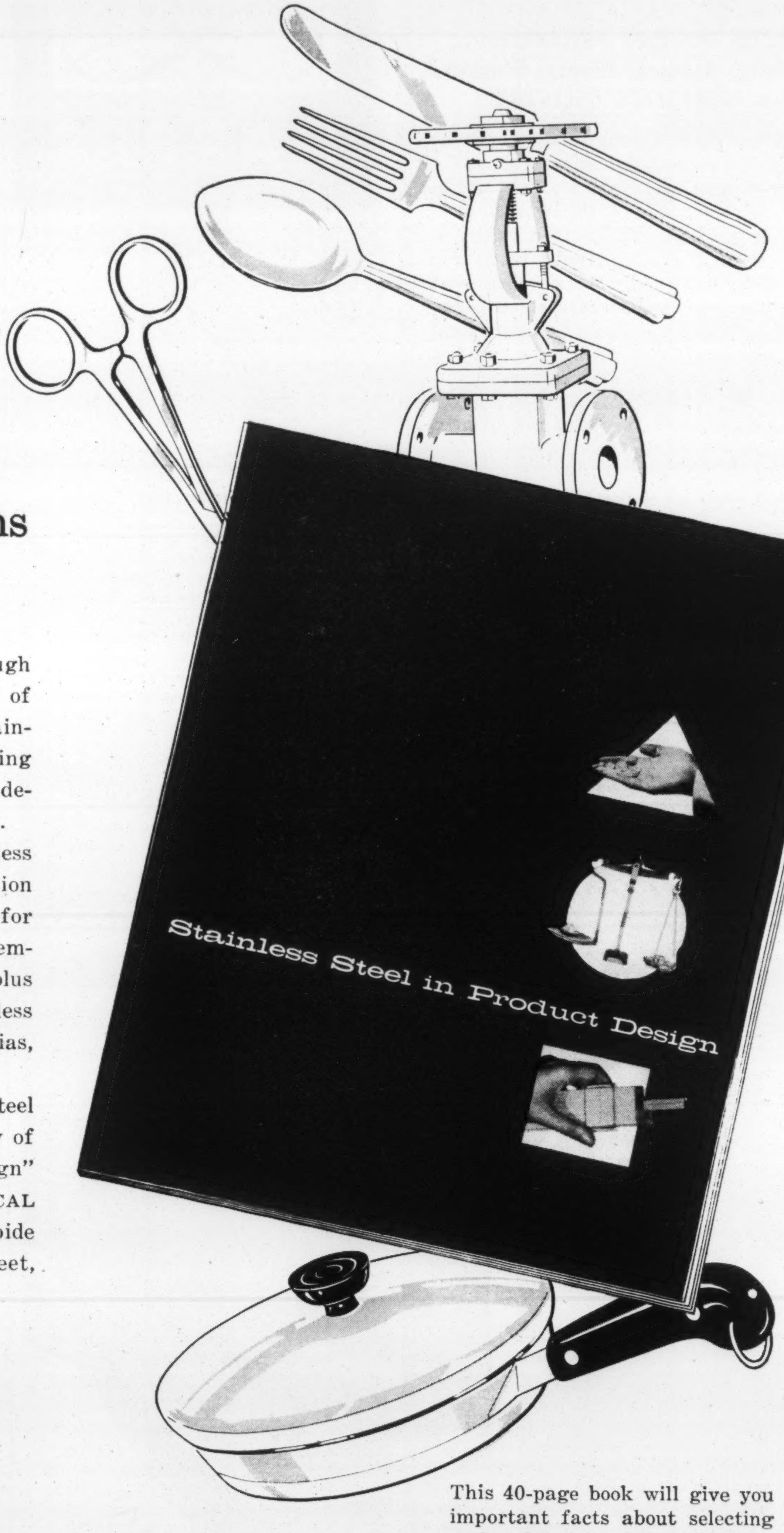
The insulating core of the curtain wall consists of a 1-in. thick layer of lightweight concrete, anchored to the outside face by clips. The remainder of the core is made up of a 1-in. thick board of fiberglass held between the concrete and the inside steel face. When the panels are fixed in place, the wall is completely finished.

New Phone Is Molded of Styrene-Acrylonitrile

A new concept in telephone design—a 9¼-in. high, one-piece unit with the dial located in the underside of the base—is being



***Molded styrene-acrylonitrile** phone has transmitter, receiver and dial (in base) all in one compact unit.*


Stainless Steel in Product Design

STAINLESS STEEL MAKES THE DIFFERENCE

...its effect on the sale of new designs

Designers gain prominence through the effectiveness and saleability of their work. The sales appeal of stainless steel is a powerful tool for selling new designs. It has turned many design ideas into profitable products.

The recognized merits of stainless steel, such as strength and corrosion resistance, make it equally "right" for housewares, jet engine parts, or chemical equipment. These qualities plus a variety of finishes have put stainless into planes, trains, cars, cafeterias, and scores of other places.

For more facts about stainless steel see your supplier. For a free copy of "Stainless Steel in Product Design" write: Electro Metallurgical Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

This 40-page book will give you important facts about selecting and applying stainless steel. Write for it today.

METALS DO MORE ALL THE TIME
...THANKS TO ALLOYS

Electromet
FERRO-ALLOYS AND METALS

UNION CARBIDE

The terms "Electromet" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

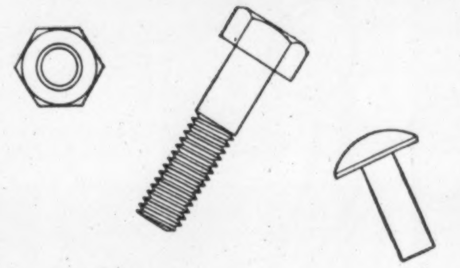
For more information, turn to Reader Service card, circle No. 489

150,000,000 Standard Fastenings . . . Bolts, Nuts, Screws, Rivets, Washers ready for IMMEDIATE DELIVERY

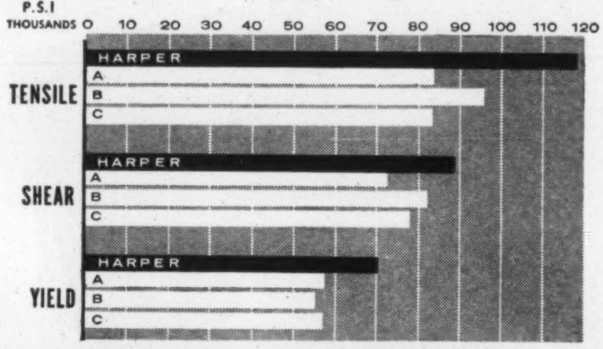
Be Specific . . . Don't Compromise . . . get the exact corrosion-resistant fastenings you need—right away—from your nearby Harper Distributor. He stocks thousands and thousands of them to give you quick service. He's an expert in fastenings and will give your order specialized attention. Why shop? Why wait? He has what you need . . . on hand BEFORE you order. They're as near as your phone. Call your local Harper Distributor today for immediate delivery.

THE H. M. HARPER COMPANY
8201 LEHIGH AVENUE · MORTON GROVE, ILLINOIS

HARPER®

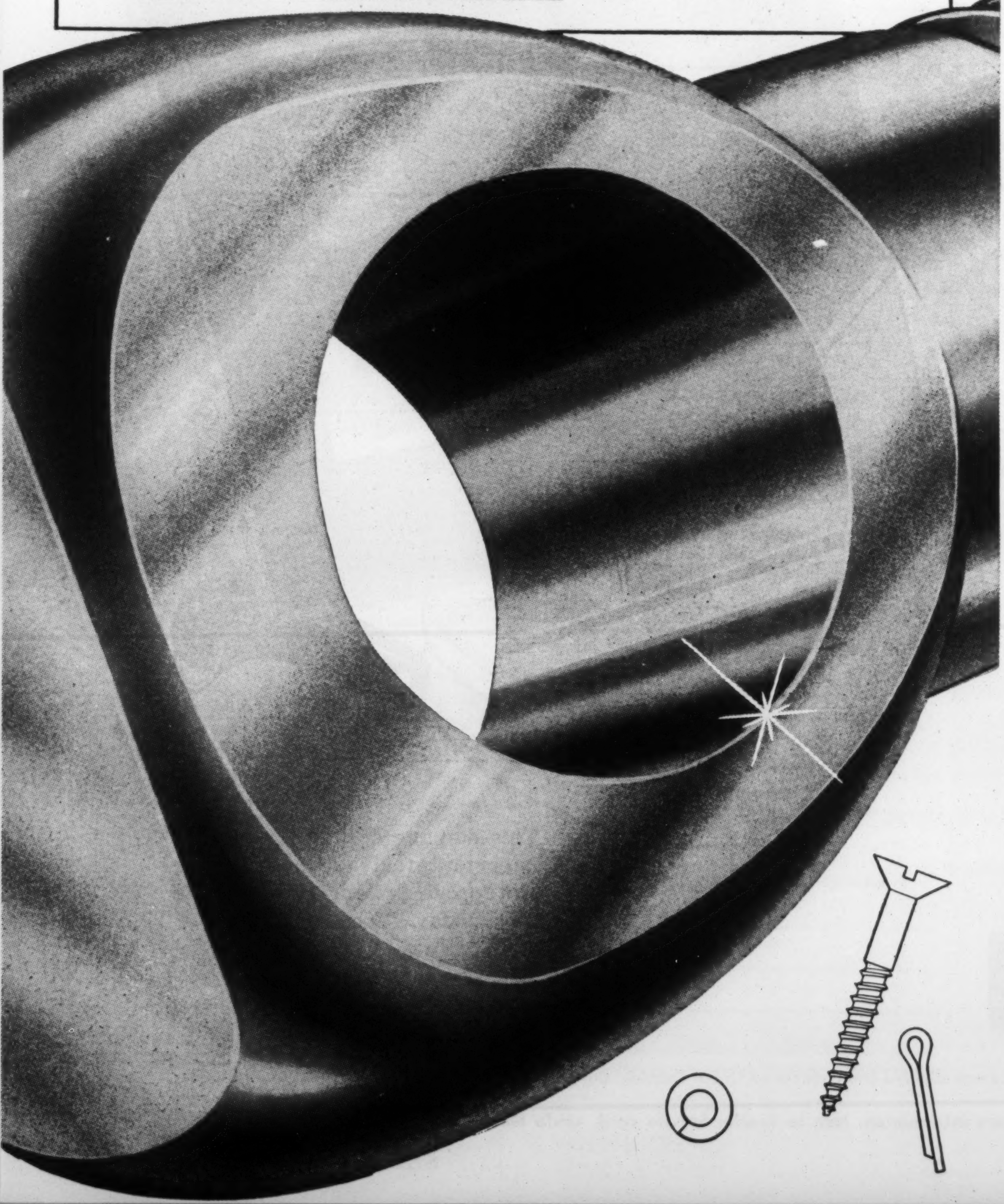


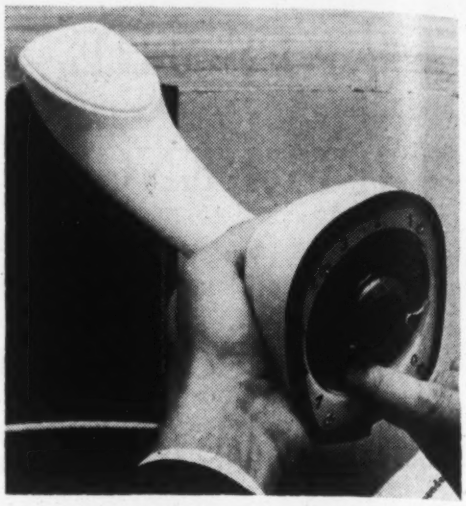
Irrefutable proof of Harper's greater metals' strength shown by laboratory test!



An important point in buying fastenings is strength. Independent laboratory tests*, utilizing Stainless Steel Machine Bolts by Harper and three other leading producers, prove Harper superiority in Tensile, Shear, and Yield Strength. The chart at left shows the actual results of these tests. For complete information on these important tests, request Form No. 126.

*By R. W. Hunt Laboratories





***Dial and line connector** are placed in base of phone for convenience.*

molded of a styrene-acrylonitrile copolymer.

The new phone, called Ericofon and manufactured by North Electric Co., incorporates several new design features:

1. A "standswitch" placed in the underside of the base and in the center of the dial (see photo), performs the usual line-connecting operations. When the phone is lifted, the line is connected; when replaced, it is disconnected.

2. The receiver and transmitter are located in the upper and lower portions of the one-piece unit.

3. As a result of the concentration of components, electrical connections are kept to a minimum. Compared to conventional phones, the number of soldering joints, terminal screws, wiring, etc., has been reduced by nearly 50%.

The selection of styrene-acrylonitrile copolymer (supplied by Union Carbide Corp.) was based on several factors: light weight; resistance to impact, scratches and stains; and availability in a variety of colors.

First Welding Fittings Forged of Zirconium

What are believed to be the first welding fittings of zirconium and Zircaloy 2 have been forged by

◀ For more information, circle No. 520

Tube Turns, Div. of National Cylinder Gas Co.

The fittings, designed for a nuclear energy application, are claimed to provide excellent resistance against the attack of a wide variety of corrosives; are relatively strong at moderately high temperatures; and have a low thermal neutron absorption cross section. The fittings are available with 1.5-in. o.d. and 0.065-in. wall.

Chromium Plated Steel Is Better Potting Mold

A new method of potting electrical connectors on missile and aircraft wiring harnesses is said to save 10 min on each operation as well as to eliminate messy molds.

Developed by Chance Vought Aircraft, Inc., the new method makes use of chromium plated

Zirconium vessel—Shown here is what is claimed to be the first commercially produced zirconium reaction vessel. Fabricated by Pfaudler Co., Rochester, N. Y., the 2-gal vessel is said to have outstanding resistance to selected environments. In the planning stage are zirconium vessels ranging in size up to 1000 gal.

For more information, circle No. 521 ➤

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This small but tricky eyebolt (reproduced here in giant size) was redesigned and produced by Harper at a 50% saving. The Harper Flo-Form Process employs highly special techniques to produce parts of economical design, with greater strength and durability, and *without* scrap loss. Call on the Harper Flo-Form engineering team of design, metallurgical, and tooling specialists to help you save dimes to dollars on parts which you find costly to manufacture. Use their more than 33 years of know-how. See what you, too, can save on corrosion-resistant fastenings and special parts. Send your problem today to The H. M. Harper Company and ask for the Flo-Form catalog.

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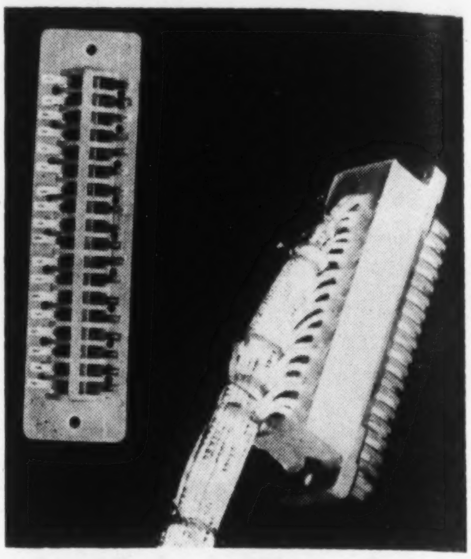

New potting method *uses chromium plated steel mold. The clear plastic covering the bottom of the finished product (right) is peeled off and remelted.*

steel molds instead of aluminum molds previously used.

With chromium plated steel molds, sticking is completely eliminated. To keep the molten resin from leaking through the mold and fouling up the electrical parts on the open face of the connector, the mold with the connectors in it is dipped into a liquid bath of cellulose acetate butyrate resin. When dry, the resin forms a cap which seals off the exposed portion; afterwards, it is easily wiped off and remelted.

With aluminum molds, either the polysulfide resin potting compound stuck to the metal and had to be scraped off, or, if a petrolatum coating was smeared inside the mold, this had to be wiped off after each operation.

No Metal Contact in New Ladling Unit

Composed entirely of special refractory materials, a new automatic ladling unit is designed so that the molten metal being ladled cannot come in contact with any metal structure. Manufactured by Lindberg-Fisher Div., Lindberg

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vinyl sheeting

for lamination to metals

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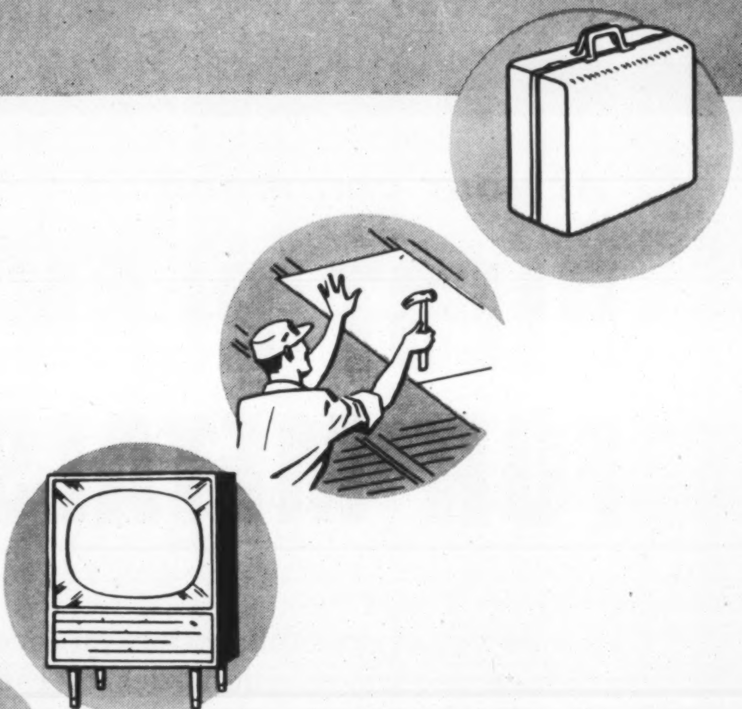

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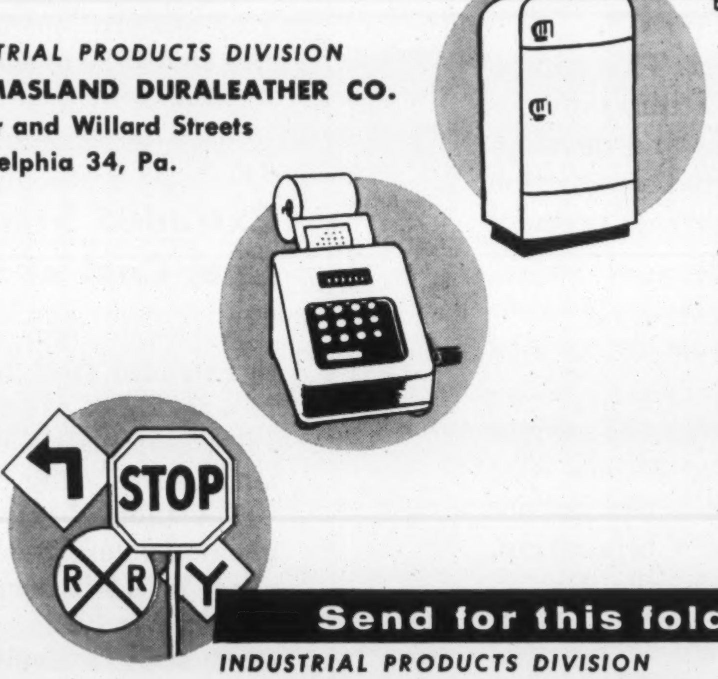

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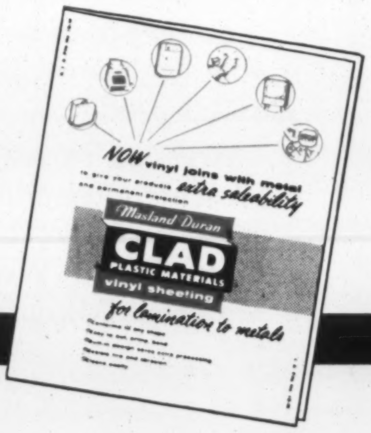
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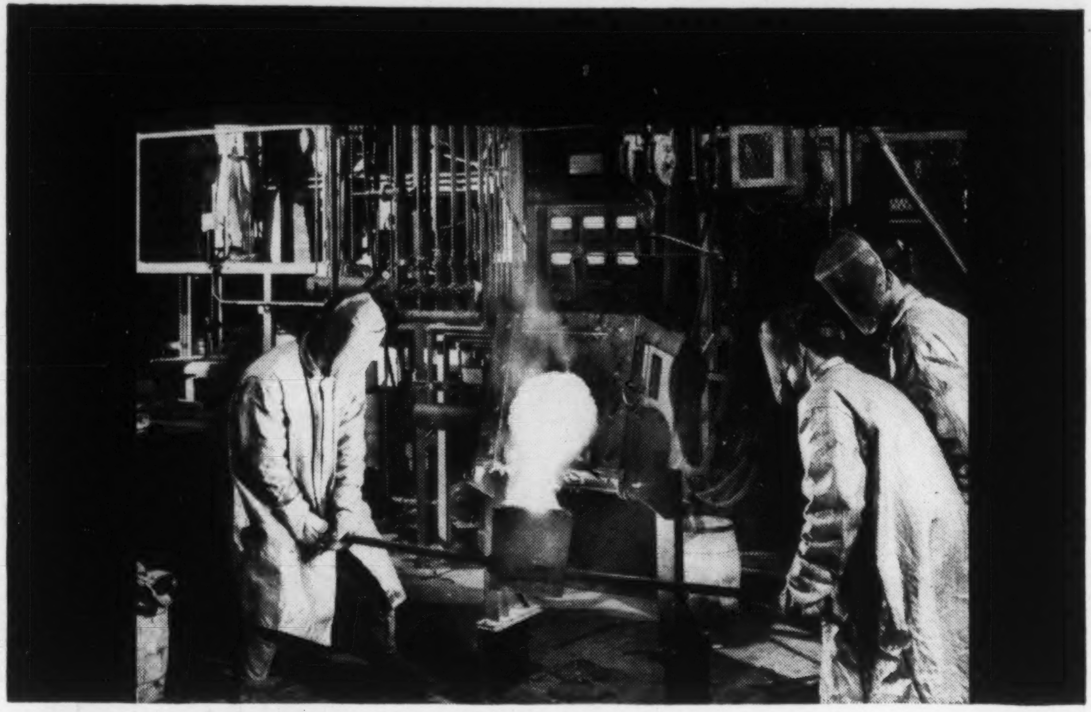

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J-05004

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Engineering Co., the unit is used in the processing of many types of castings, especially aluminum die and permanent mold castings.

Flexible Plastics Plate May Cut Printing Costs

A presensitized, lightweight, flexible plastics printing plate designed for use in letterpress printing, has been developed by the Photo Products Dept. of E. I. du Pont de Nemours & Co., Inc.

The plastics printing plate is ready for use after exposure through a high contrast photographic negative and washing in a simple water solution. A chemical change in the light sensitive plastic during exposure forms an image on the plate and unexposed areas are "washed out," leaving a relief of up to 0.040 in. Du Pont says that field testing of the plastics printing plates will begin this year and that commercial quantities should be available some time in 1959.

Extruded Steel Tubing Cuts Cost of Inserts

A switch from solid steel bar to extruded steel tubing resulted in a saving of 47¢ per ring on the valve seat inserts used by Cleveland Hard Facing Co.

The tubing, extruded by Allegheny Ludlum Steel Co., is supplied in 11-ft lengths. Outside diameter is 1.9 in. In addition to eliminating a drilling operation, the extruded tubing yields 2½ times as many rings as does an equal weight of solid bar stock.

Tubing *makes cheaper rings.*

PRICES AND SUPPLY

The Outlook

by Herman B. Director, *Consultant, Washington, D.C.*

Aluminum production and prices increased

By mid-1959, increasing aluminum production is expected to add 680,000 tons to the present U.S. capacity of 1,775,000 tons—an increase of approximately one-third. There are some observers who feel that this is more aluminum than is needed.

In the meantime, the price of primary pig has been increased by 1¢ per lb. (The increase, incidentally, is reported to average out at about 4%. The recent steel increase was also reported to average 4% and this coincidence will no doubt whet the appetites of Congressional investigators who are now in the midst of large scale hearings on "administered prices.")

The price increase comes at a time when consumption is down about 10% and producer inventories are at high levels. Two things seem to be apparent:

1. The increase in aluminum price coupled with the drop in the price of copper, reduces the price advantage which aluminum has had over copper. Since 1947, aluminum had enjoyed a sharp price advantage and had gained as a replacement material in construction and electrical applications.

2. The metal which the aluminum producers now "put" to the Government under their contracts will go to the Government at the higher price since the contracts provide for the Government to pay the prevailing market price at the time "put."

Zinc 'tax' will raise prices

Imposition of a tariff or "tax" on importation of zinc will have widespread effects on prices of many widely used materials. Zinc is vital for construction, for the automotive industry and for die castings. Any increase in the price of zinc is immediately applied to all products using zinc.

Another important aspect of the imposition of a tariff on zinc is the broader implication with regard to tariffs on other metals and minerals. Certain groups are already preparing presentations for similar treatment. Materials involved are chromium, tungsten, manganese and fluorospar, all of which are used in the production of basic steel.

Tariff increases on these materials, on top of the zinc and lead duty, lay the foundation for another round of price increases even before the latest increase in steel prices has settled down. Producers of zinc-bearing materials such as copper tubing are also attempting to use the zinc tariff as a basis for protection of their copper products. The net effect of all this is that the product manufacturer will pay the bill and presumably will have to pass the increase along to the ultimate consumer.

Plywood consumption up, prices down

Plywood prices continue to decline in spite of the fact that consumption for home building is increasing —1957 usage thus far is 11% higher than it was in 1956 and nearly double that of 1954. Primary reason for this seems to be an oversupply of plywood.

Platinum prices cut

The price of platinum has dropped $8 per oz, from $92-95 to $84-87 per troy oz. Conditions which prevailed at the time we forecast a price decrease (MATERIALS & METHODS, Mar '57) are still in evidence, and further price drops may be in the offing. Actually, the effective market price has been below the quoted $84-87 range for some time.

Indications of another decrease in platinum prices come from reports that the jewelry trade has shifted, for the most part, to palladium, which is quoted at $23-24 per oz. (Small lots are reported to be available at as low a price as $16 per oz.)

Cobalt in plentiful supply

Now that the Government has virtually ended its cobalt stockpiling program, there is an abundant supply of cobalt available. World production has increased from 7,100 tons in 1950 to 16,000 tons in 1956, and since cobalt uses were severely restricted

The Outlook—continued

during wartime emergencies, engineers generally tended to design away from cobalt. In addition, now that nickel is easier to get, less cobalt is being used for alloy steels. New technology in magnets has even reduced cobalt's use there. The only constant area of consumption left seems to be in the chemical industry where it is used as a pigment or drier.

Zirconium and hafnium production to increase

Production of zirconium and hafnium is expected to increase sizably this fall as a result of new production facilities. The new facilities will produce a wide variety of mill products and ingots. Uses for these products should grow as industrial applications for atomic energy are increased.

Plastics use in autos growing

Use of plastics in automobile interiors has increased remarkably in the last five years. Consumption of vinyl upholstery, for example, has increased from slightly over 5 million pounds in 1950 to over 45 million pounds in 1955. In fact, vinyl accounted for 13% of all materials used in fabrics in 1955, compared with only 2% in 1950.

On the other hand, although cotton use increased from 197 million pounds to about 210 million pounds, its relative position in so far as auto fabric use is concerned decreased from 62% in 1950 to 55% in 1955.

Use of wool declined from 33 million pounds in 1950 to slightly over 1 million pounds in 1955. In terms of percentages this represents a drop from 10% to less than 1%.

Although the vinyls seem to have it, a new trend is starting which seems to be turning in the direction of other plastics materials, especially nylon and Orlon.

Though consumption of plastics materials for passenger cars is likely to keep increasing, there is no danger of a scarcity. Production of virtually all plastics upholstery materials has been greatly expanded and monthly production of vinyl alone exceeds seven million pounds.

Nickel expansion goal closed

At about the same time that the United States Government announced it would offer no further incentives to encourage the expansion of primary nickel production (see MATERIALS & METHODS, June '57) the British announced that they had decided to sell nickel from their strategic stockpile. Speculations as to whether the United States will do the same run into a blank wall: U.S. stockpile disposal laws are much more rigid than Britain's.

Nevertheless, the existence of huge stocks of materials in the face of indicated cut-backs in the aircraft program, may pose serious problems. The huge expansion plans initiated by International Nickel Co. of Manitoba are going ahead on schedule, and although nickel supplies are still insufficient to meet needs (that is, at the 74¢ market price), nickel can be obtained fairly easily.

Copper cut-backs may not work

Although major U.S. producers have cut back on copper production in an attempt to balance the supply-demand picture, Rhodesian and Chilean producers have thus far shown little inclination to do the same. Rhodesian producers have actually announced substantial increases in production by 1960.

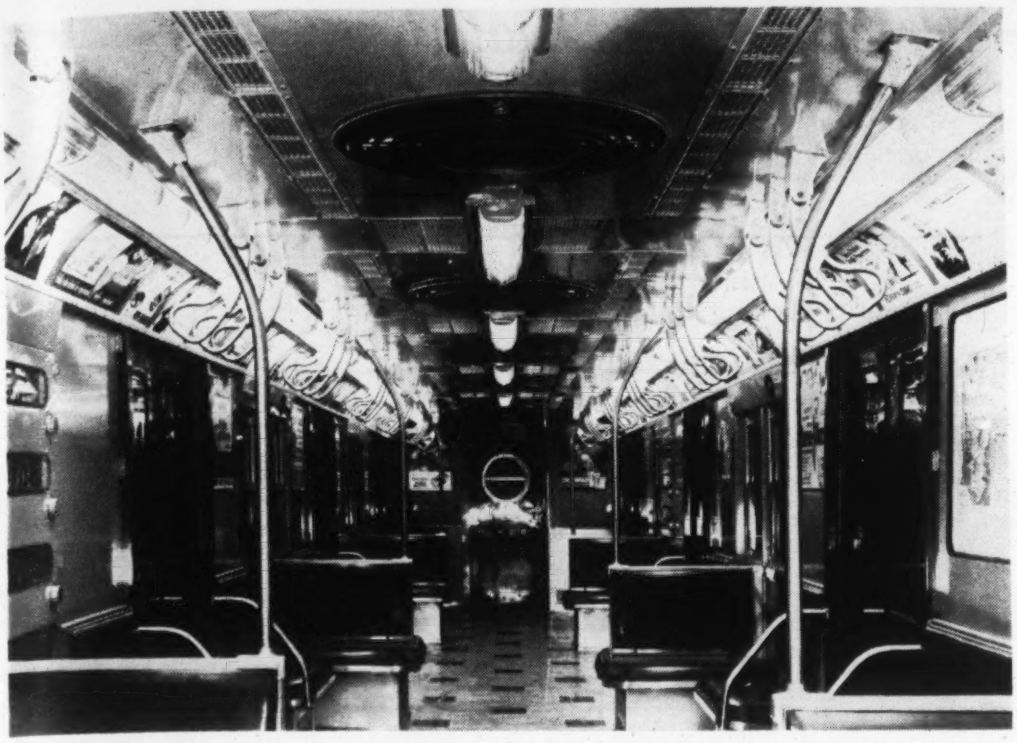
Conditions in Chile, however, are much more important. In fact, if the Chileans do not decrease their copper output, it will be impossible to reduce the huge oversupply of copper. The prospect at the present time, therefore, seems to be that the U.S. will offer a concession to the Chileans in the form of a tacit agreement to maintain further Chilean exploration and production in order to keep Chile's proportion of world markets at present or even increased levels. It seems to us, that this agreement can have little or no actual effect on copper prices.

Director on Subsidies

Conflicting statements out of Washington continue to confuse the metal markets. While the Interior Dept. and the Congress make daily comment on subsidies, tariffs, barter and taxes as a promise of better prices, the Agriculture Dept. is equally firm in its insistence that barter deals can be expected to fall off.

The Agriculture spokesman, in testifying before Congress, emphasized that barter transactions were aimed primarily at moving farm goods and not at bolstering prices of domestic metals and minerals. Actually, barter transactions tend to bolster world prices rather than just U. S. prices. As for direct subsidies in the form of Government purchases, the outlook is good from a consumer point of view in that tungsten props are out and other materials purchases will be at a minimum and of short duration. The original $90 million proposed purchase program now stands at $8.7 million.

Production cuts by major producers of zinc, lead, copper and other materials, however, confirm the lack of confidence in the Government's ability to 1) suport U.S. prices directly, 2) support free world prices indirectly, and 3) indirectly support Communist bloc production if barter opportunities are opened to the Reds.



Increased use *of porcelain enamel on aluminum is forecast by use of this material for such things as ceilings in subway cars.*

Porcelain Enameled Aluminum Will Get Big Boost in Use

Use of porcelain enamel on aluminum is expected to increase from the 3.5 million square feet used in 1956 to 5.2 million square feet this year, according to a recent forecast released by the Porcelain Enamel Institute's Aluminum Div. This estimated expansion represents a gain of approximately 50%.

The building industry was the greatest single consumer of porcelain enameled aluminum in 1956, accounting for 2.4 million square feet. This year the figure is expected to be about 3.8 million square feet. Other major uses include appliances, utensils, signs and military applications.

PREDICTED CONSUMPTION OF PORCELAIN ENAMEL ON ALUMINUM[a]

Use↓	1957	1961
Building Materials	3,800	15,000
Signs	250	2,600
Appliances	200	2,000
Transportation	200	600
Sanitary	—	200
Utensils	300	1,100
Military, Other	450	1,500

[a] 1000 sq ft.

By 1961, the Institute says, the total market for porcelain enamel on aluminum is expected to increase to 23 million square feet—a 500% growth. This prognostication is based on the following four factors:

1. There is every reason to believe that there will be a continued increase in the use of existing applications in the building field. Furthermore, new applications, such as window parts, doors, hardware, ceiling panels (see photo) and railings, are expected.

2. The large highway program recently passed by Congress is expected to play an important role in expanding the sign market during the next five years.

3. By 1961 applications of porcelain enameled aluminum in the automotive industry are expected to be extensive.

4. Both decorative and functional applications of porcelain enamel on aluminum are expected to increase in major and small appliances.

Tinplate, Tin Products Get New Pricing Rules

The present practice of making firm commitments for six months' pricing periods for tinplate and other tin mill products is expected to be discontinued at the end of the year. Beginning Jan 1, 1958, tin mill products will be billed on the basis of prices ruling at the time of shipment. It is understood that present prices for tinplate, which are effective through Oct 31, will probably be extended to Dec 31.

Steel Capacity in U.S. Up 47% in Ten Years

Ten years ago the nation's steel mills would have had to operate at 130% of the then-rated capacity in order to produce as much steel as was turned out during the first half of this year. Yet, during the first half of this year steel mills operated at only 91.5% of capacity.

According to the American Iron and Steel Institute, the Jan 1, 1957 capacity was 133,459,150 net tons of ingots and castings per year, compared with 91.2 million net tons annually in 1947. Even in 1950, the Institute says, an operating rate averaging over 120% of capacity would have been required to make an amount of steel equivalent to the 60 million tons produced during the first half of 1957.

What's Happening in Prices and Supply

Fluorocarbons — Du Pont has announced a major expansion of its Teflon producing facilities. According to the plans, the output of Teflon 1 and 5, used for compression molding and ram or screw extrusion, will be increased by 30% by mid-1958. By late 1957, production of Teflon 6 and Teflon 30, used for corrosion resistant flexible tubing and insulation for high

(continued on p 246)

Prices of Materials

Changes since last month are bold-faced

NONMETALLICS

Prices for large quantities for range of grades, color, sizes; given in $/lb

RUBBER

Material	Dry	Latex
Butadiene-Acrylonitrile	.49-.65	.44-.54
Butadiene-Styrene	.17- 30	.26-.32
Butyl	.23-.28	—
Neoprene[a]	.39-.75	.37-.47
Silicone[a]	1.90-4	—
Polysulfide[a]	47-1	.70-.92
Natural	.33[b]	—

[a] Less than carload quantities.
[b] Average spot price for month of Apr.

GLASS FOR REINFORCED PLASTICS

Fabric ($/yd 38 in. wide)[a]	
112 Woven	.48
181 Long-shaft satin weave	.03
143 Unidirectional	1.00
Roving[a]	
Continuous	.40
Continuous spun strand	.36
Continuous chopped spun	.38
Milled fibers (1/32-¼ in.)[a]	.45
Mat	
Chopped strand (2 in.)[a,b]	.52-.72
Surfacing ($/1000 sq ft)[c]	10-19
Continuous chopped strand (¼-2 in.)	.40

[a] Price includes binder or finish.
[b] Price varies with binder.
[c] 0.010-0.020 in. thick.

THERMOSETTING PLASTICS

Material	Molding Compounds	Laminating, Casting Resins
Alkyd	.34-.53	—
Epoxy	—	.45-.80
Melamine	.42-.45	.40-.41
Phenolic	.20-.40	.17-.34
Polyester	.42	.32-.50
Silicone	2.75-5.40	1.55-1.74[a]
Urea	.19-.33	—

[a] 60% solids content.

All prices are approximate and given solely for general guidance of those responsible for materials selection.

THERMOPLASTICS

Material	Molding Compounds	Sheet (.030-.250 in.)	Rod		Tube	
			⅛-¼ in.	⅜-1¼ in.	⅛-¼ in.	⅜-1¼ in.
Acrylic	.51-.59	.49-2.15	.90-1.15	.80-.90	1-1.15	.90-1
Cellulosic						
Acetate	.36-.65	.92-1.16	.75-1	.65-.75	.85-1	.75-.85
Butyrate	.50-.72	1-1.28	.95-1.20	.85-.95	1.05-1.20	.85-1.05
Nitrate	—	1.60-2.73	1.45-1.75		2.25-5.00	
Propionate	.51-.63	—	—		—	
Fluorocarbon						
CFE	7-8	15-23	18-22	14-20	20-22.50	16-20
TFE	4.50-7.45	14.30-11	13	13	13	13
Nylon	1.35-2.30	—	3	3	3	3
Polyethylene	.35-.56	.85-1	.75-1	.65-.75	.85-1	.75-.85
Polystyrene	**.26**-.44	.57-.61	.65-.90	.55-.65	.75-.90	.65-.75
Vinyl	.27-.43	.62-.92	.75-1	.65-.75	.85-1	.75-.85

NONFERROUS METALS

Mill base prices for large quantities; given in $/lb except where indicated

ALUMINUM

Pig (99-99.9%)	**.26**-.27
Ingot (99-99.9%)	.27-.29
Foil (5-0.5 mil)	.55-.77
Alloy Ingot (13, 43, A132, 214)	.29-.32
Sheet (1100, 3003; 3-.03 in.)[a]	.40-.45
Plate (1100, 3003, 5050, 3004, 5052)[a]	.40-.43

[a] Mill finish.

BRASS

Form	Cart., 70%	Low, 80%	Red, 85%
Sheet, Strip	.45	.47	.48
Seamless Tubing	.48	.50	.51
Rod (not f.c.)	.44	.47	.48
Wire	.45	.48	.49

COPPER

Ingot (elec)	.29
Sheet, Strip (hot rolled)	.51
Seamless Tubing	.52
Rod, Drawn	.49
Rod, Free Cutting	.58
Wire	
Round	.35
Square, Rectangular	.38
Magnet	.42

LEAD

Common Grade	.14

MAGNESIUM

Pig (98.8%)	.36
Ingot (98.8%)	.37
AZ91B Ingot (die casting)	.37
AZ91C Ingot (sand casting)	.41[a]

[a] Delivered price.

NICKEL

Form	"F"	"A"	Monel
Ingot	75[a]	—	—
Rod	—	1.07	.89
Sheet, C.R.	—	1.26	1.06
Strip, C.R.	—	1.24	1.08
Seamless Tube	—	1.57	1.29

[a] Delivered price.

TIN

Primary[a]	.97

[a] Delivered price.

(continued on p 242)

Dust Flies Fast and Furious

. . . when the TRAXCAVATORS* go into action!

CUTAWAY of a Caterpillar No. 955 Traxcavator to show one of the spots protected by seals of American Felt.

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For more information, turn to Reader Service card, circle No. 510

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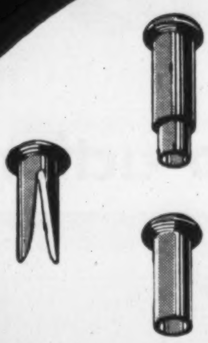
will reduce your Fastening Costs



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Semi-Tubular, Split and Shoulder

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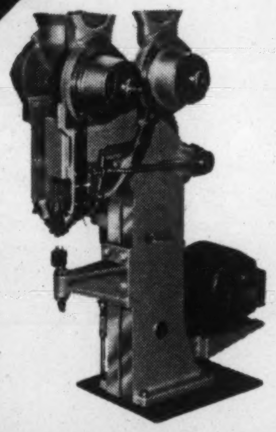
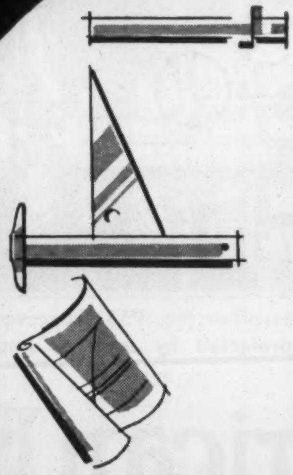


rivet setters

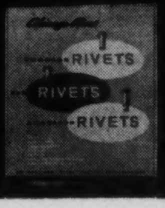
Your fastening costs are less because Chicago Rivet makes machines that set from one to seven rivets at a time. Riveting is automatic and may involve the use of special indexing fixtures, adjustable riveting centers, and top or bottom rivet feeding and other mechanisms, controlled by solenoids or air cylinders or both.



engineering

The recommendations of Chicago Rivet Engineers are most valuable. Their knowledge of rivet fastening techniques, gained from solving thousands of manufacturers' fastening problems can help make your product more competitive. Calling Chicago Rivet is a habit-formed procedure with many companies. You incur no obligation when you use the service of Chicago Rivet Engineers. Send a blue print or sample assembly with your inquiry.

Chicago Rivet & MACHINE CO.
9628 WEST JACKSON BOULEVARD
BELLWOOD (CHICAGO SUBURB) ILLINOIS
BRANCH FACTORY: TYRONE, PA.



New Rivet Catalog contains engineering data, list of popular semi-tubular, full tubular, split and shoulder rivets and popular automatic rivet setters. Write for copy.

For more information, turn to Reader Service card, circle No. 498

TITANIUM

Sponge (99.3+%)	2.00-2.50
Bars, Rod	6.15-6.40
Plate	8.00-10.75
Sheet, Strip	6.50-11.10
Wire	7.50-8.00

ZINC

Primary[a]	.10½[c]
Die Casting Alloys[b]	.15-.16
Sheet	.24
Ribbon	.21
Plates	.19

[a] Prime Western—Special High Grade. [b] Alloys 2, 3, 5. [c] Delivered price.

METAL POWDERS

Aluminum[a,b]	.36
Brass[a]	.34-.43
Copper (elec or red.)[a]	.43
Columbium	120
Molybdenum (98%)	3.80-4.10
Nickel	1.05
Tantalum	49
Tungsten (C-red. 98.8%; H_2-red. 99+%)	4-5[c]
Zirconium	
Flash Grade	11.50
Electronics Grade	15

[a] Price for —100 mesh. [c] Delivered price.
[b] Freight allowed.

OTHER NONFERROUS METALS

Cadmium (bars)	1.70
Gold	$35/troy oz
Indium (99.97+%)	$2.25/troy oz
Manganese (99.9%)	.34[a]
Palladium	$23-24/troy oz
Platinum	$84-87/troy oz
Silver	91¢/troy oz
Tantalum (sheet, rod)	55-60
Vanadium	3.45
Zirconium (sheet, strip, bar)	27-35

[a] Delivered price.

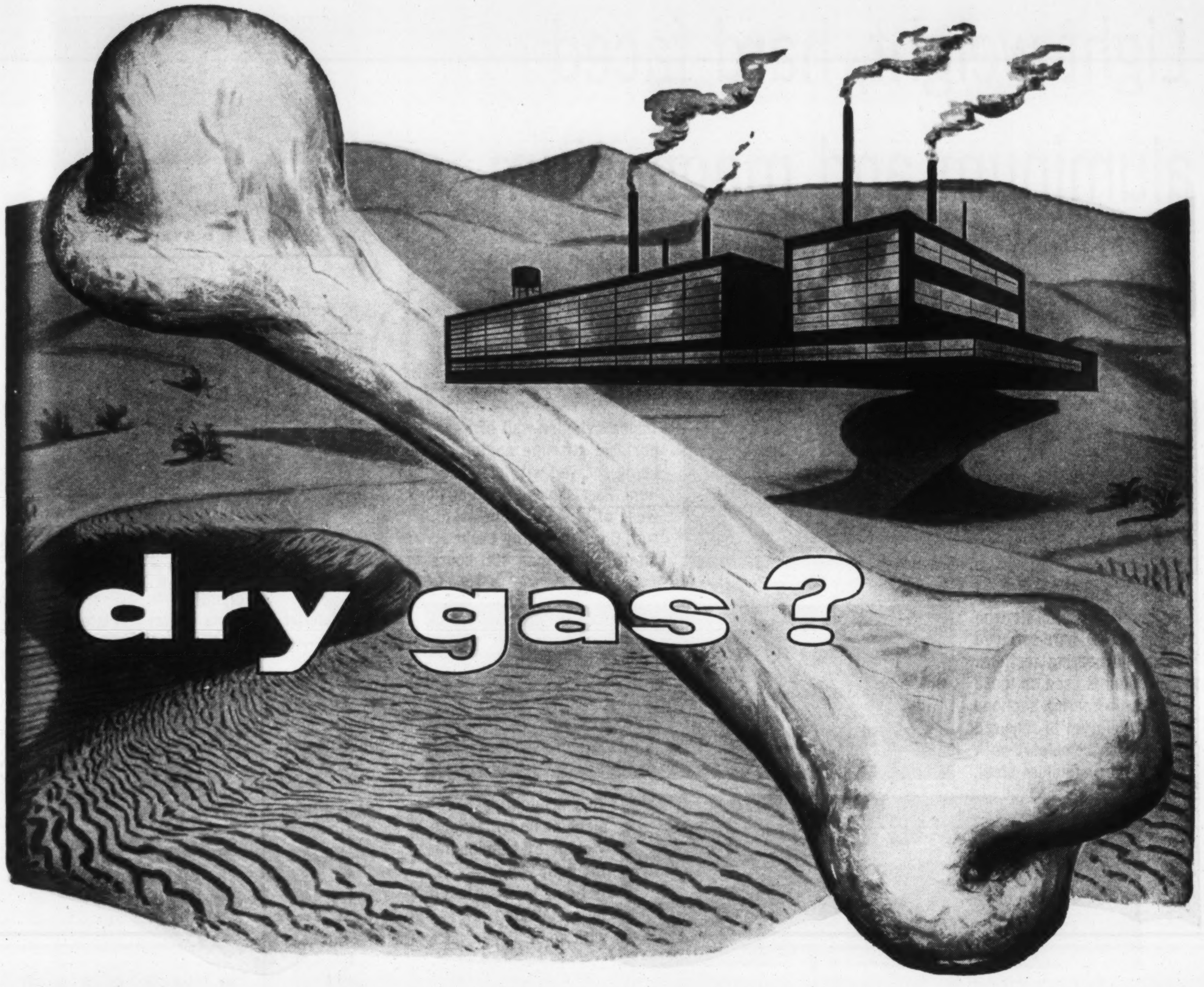
IRONS AND STEELS

Mill base prices for large quantities

SEMIFINISHED STEEL ($/net ton)

Ingots, Alloy	77
Billets, Blooms, Slabs	
Carbon, Re-Rolling	77.50
Carbon, Forging	96
Alloy, Forging	114
Seamless Tube Rounds	117.50
Wire Rods	$6.15/cwt

(continued on p 244)

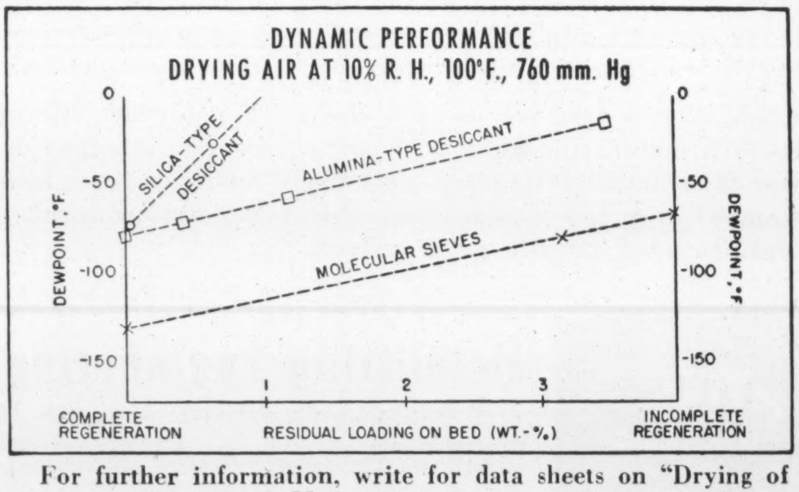


Now you can dry gases drier than dry!

LINDE Molecular Sieves can dry your gases—air, hydrogen, chemical streams—more thoroughly than any other commercial adsorbent. They will duplicate laboratory performances—*in your plant*—under normal *production* conditions.

Even though your gas stream may already be partly dried, Molecular Sieves will remove the last traces of moisture. Only a small volume of adsorbent is required. The same combination of high capacity and low dewpoint is also obtained at high temperatures, up to 200°F.

This is SUPER-drying! Dynamic performance is shown in the accompanying graph. This superior performance also can be expected at higher relative humidities and at other temperatures and pressures. Of particular significance in production is the relative insensitivity of Molecular Sieves to incomplete regeneration.



For further information, write for data sheets on "Drying of Gases." Address Dept. N-9, Linde Company, Division of Union Carbide Corporation, 30 East 42nd St., New York 17, N. Y.

The terms "Linde" and "Union Carbide" are registered trade-marks of UCC.

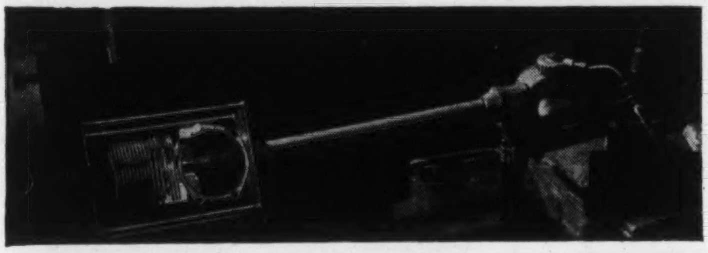
Linde
TRADE MARK
MOLECULAR SIEVES

UNION
CARBIDE

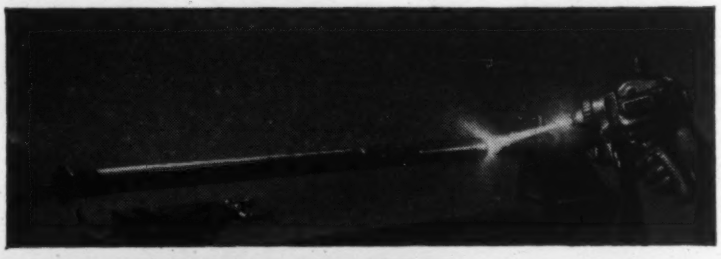
For more information, turn to Reader Service card, circle No. 569

Light weight, hard-faced aluminum and magnesium outwear steel

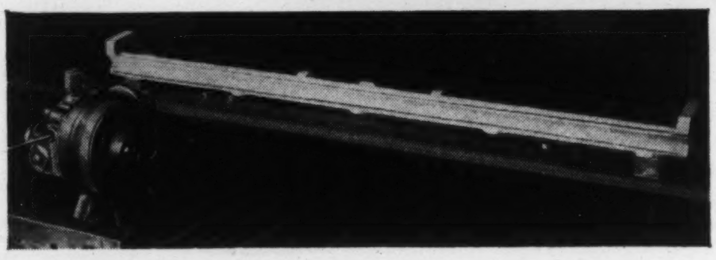
Molybdenum, steel or stainless sprayed coatings, applied at high speed and low cost, offer many opportunities for product improvement.



Inside cylinder wall of portable gasoline engine being sprayed with molybdenum. Part showed little or no wear after 4,000-hour test run. Chrome-plating broke down in less than 400 hours.



Aluminum torque tube, used in control of aircraft trim tabs, being hard-surfaced at end bearing sections. Molybdenum is used on these press-fit bearing sections and build up to required dimension completed with hard stainless steel.



This accounting-machine undercarriage—made of aluminum for light weight—is being hard-surfaced by metallizing with steel.

A wide range of hard metals, including molybdenum and hard stainless steel are being applied to light weight metals to provide even longer service life than is possible with solid steels, yet retaining the weight-saving advantages.

Application is relatively simple—fast, modern metallizing guns will spray over 20 pounds of stainless steel per hour. This, in the comparatively thin coatings used, usually ranging from .003" to .010", spells high-speed surface coverage. Semi-automatic control equipment is available for production line operations. Free operator training and on-the-spot service is supplied by full-time, company-trained, field engineers.

For further information send off the coupon attached or even better, write, giving us some idea of the application you have in mind.

METCO

Metallizing Engineering Co., Inc.
1175 Prospect Ave., Westbury, L. I., New York • cable: METCO
In Great Britain: Telephone: EDGEWOOD 4-1300
METALLIZING EQUIPMENT COMPANY, LTD.—Chobham near Woking, England

Please have a field engineer call upon me.

NAME

TITLE

COMPANY

ADDRESS

CITY STATE

For more information, turn to Reader Service card, circle No. 536

PRICES AND SUPPLY

FINISHED STEEL ($/cwt)

Form	Carbon	High Str Low Alloy	Alloy
Plate	5.10	7.62	7.20
Sheet, H.R.	4.92	7.27	—
Sheet, C.R.	6.05	8.97	—
Strip, H.R.	4.92	7.32	8.10
Strip, C.R.	7.15	10.65	—
Bar, H.R.	5.42	7.92	6.47
Bar, C.F.	7.30	—	8.77

STAINLESS STEELS ($/lb)

Material	Forging Billets	H. R. Bars	Plate	Sheet, Strip
Austenitic				
301, 302, 302B, 303, 304, 305	.38-.41	.44-.48	.46-.51	.51-.59
321[a]	.47	.56	.60	.66
347[a]	.56	.65	.70	.80
Martensitic				
410[a]	.28	.34	.35	.40
416	.29	.34	.35	.47
403	.32	.38	.40	.48
420, 440	.34	.41	.45	.62
Ferritic				
405, 430, 430F[a]	.30	.34-.35	.36-.38	.41-.47
442	.32	.38	.40	.56
431	.30	.35	.46	.54
446	.38	.45	.46	.67
High Mn				
202[a]	.37	.43	.45	.49
Extra Low C				
304L	.48	.56	.59	.63
316L	.64	.74	.78	.82
Precip Hard.				
17-7PH	**.66**	**.73**	**.85**	**.90**

[a] Ingot prices approx 60% of forging billet price.

METAL POWDERS ($/lb)[a]

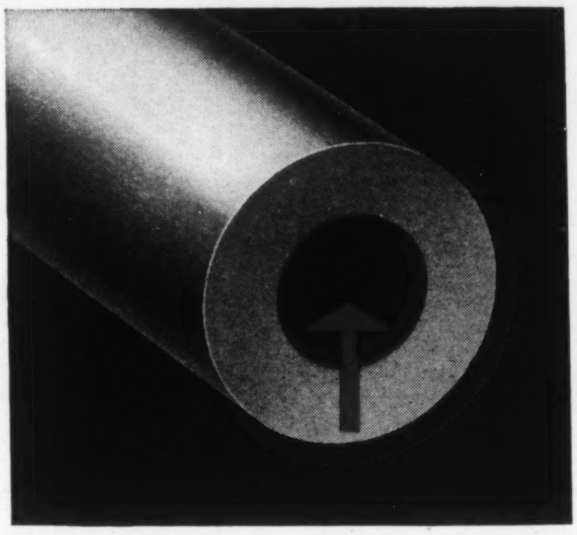
Sponge Iron	.10-.11
Electrolytic Iron	
Annealed (99.5%)	.37
Unannealed (99+%)	.34
Stainless Steel	
304	1.08
316	1.44

[a] Price for −100 mesh.

IRON ($/gross ton)

Pig	65-66

(continued on p 246)



a hole here makes waste...

a hole here saves waste

Crucible Hollow Tool Steel cut sections eliminate the waste and cost of drilling out solid rounds to make ring-shaped or tubular steel parts, or tools with a center hole. By using these hollow bar sections, cut to length, you do away with unnecessary cutting, drilling, and boring operations, increase machine capacity, and cut scrap losses.

These hollow sections, in just about any O.D. and I.D. combination, or thickness you want, are *immediately* available in five most popular Crucible grades: KETOS oil hardening, SANDERSON water hardening, AIRDI 150 high-carbon high-chromium, AIRKOOL air hardening, and NU DIE V hot-work tool steels.

Call your nearby Crucible warehouse for more information, or for speedy delivery. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE **first name in special purpose steels**

Crucible Steel Company of America

Canadian Distributor—Railway & Power Engineering Corp., Ltd.

For more information, turn to Reader Service card, circle No. 392

Creative Papers from the mills of Mosinee

. . . are custom-tailored to specific needs . . . particularly yours

Paper uniformity speeds production of Consoweld's laminated plastic

CONSOWELD CORPORATION manufactures a variety of lifetime wall and countertop surfacing. This laminated plastic is made by impregnating specially manufactured papers with synthetic resins. Backing up the beautiful, colorful pattern sheet are 7 or more sheets of special Mosinee paper. Not any paper will do. The one used must absorb exactly the right amount of the expensive resin. And Consoweld finds Mosinee papers' uniformity of caliper and basis weight speeds production.

Mosinee, with nearly a half-century of sulphate paper making experience, was able to develop and quantity-produce this special paper. Perhaps Mosinee Creative Papers can help solve your problems. Our technological experience is at your disposal. Simply fill out and mail the coupon.

CONSOWELD CONSTRUCTION

Mosinee PAPER MILLS COMPANY

MOSINEE PAPER MILLS CO., Dept. MM-9, Mosinee, Wisconsin

Please furnish details on how you can create special papers to meet our needs.

NAME.................................TITLE.................................

FIRM.................................

CITY.................................ZONE..........STATE.................................

ADDRESS.................................

PRODUCT.................................

For more information, turn to Reader Service card, circle No. 485

PRICES AND SUPPLY

TIN PLATE ($/base box)

Hot Dip (1.25-1.50 lb)	10.05-10.30
Electrolytic (0.25-0.75 lb)	8.75-9.40
Black Plate	7.85-7.95

FINISHES AND COATINGS

ORGANIC COATINGS

Material	Avg Thk per Coat, mil	Mils Required[a]	Cost, ¢/sq ft/dry mil[b]
VARNISHES, ENAMELS			
Short Oil Phenolic			
Varnish	1.0	1.0	1.50
Enamel	1.2	1.0	1.75
100% Phenolic	1.0	1.5	1.75
Straight Oil-Modified Alkyd	1.5	1.5	1.50
Alkyd-Amine (90-10)	1.5	1.5	1.75
Alkyd-Phenolic (50-50)	1.5	1.5	1.75
Alkyd-Vinyl (50-50)	1.0	2.0	2.0
Alkyd-Styrene (70-30)	1.2	1.5	1.75
Epoxy	1.8	1.8	2.00
Silicone	.5-1.0	.5-1.0	6.0
Furane	2.0	2.0	1.0
Neoprene	5.0	5.0	1.50
DISPERSION COATINGS			
Phenolic	1.0	1.5	1.75
Vinyl	1.0	2.0	2.50
Fluorocarbon	1.0	1.0	15.0
LACQUERS			
Nitrocellulose	1.0	2.0	2.50
Vinyl	1.0	2.0	2.50
Acrylic	1.0	2.0	2.75
Butyrate	1.0	2.0	2.75

[a] Thickness over phosphate coating required for exterior durability on steel. For purely decorative coating, 1 mil will usually suffice.

[b] Materials cost only. Realistic price comparison can be made only on basis of dry applied coating, not on basis of cost per gallon.

Fluorocarbons—continued

temperature wiring, will be doubled.

A new fluorocarbon resin, Teflon 100-X perfluorocarbon, which is claimed to have a melt viscosity low enough to permit extrusion in standard equipment (see MATERIALS & METHODS, Nov '56, p 161)

For more information, turn to Reader Service card, circle No. 566

NOW!
ACE helps you get
FABRICATED
PLASTIC PARTS
faster...at lowered costs

New e-x-p-a-n-d-e-d production facilities now give you ACE HIGH QUALITY on all types of screw machine, centerless ground parts and special shapes . . . all colors . . . all materials.

LUCITE • PLEXIGLAS • ACRYLIC • ACETATE • BUTYRATE • CAST PHENOLIC • EPOXY RESIN • ETHYL CELLULOSE • KEL-F • LAMINATED BAKELITE • NYLON • POLYETHYLENE • STYRENE COPOLYMERS • TEFLON

Sizes: 1/8" to 2 1/4" • Lengths: 1/16" to 9"

Write, wire, phone for samples, prices and bulletin listing stock items. Send specifications or blueprints for prompt quotation on specials.

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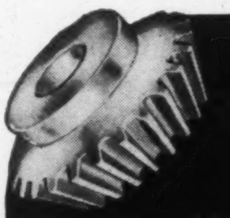
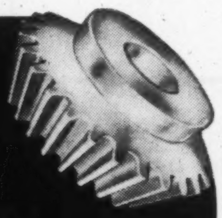
Extrusion Molders and Fabricators
91-48 Van Wyck Expressway, Jamaica 35, N. Y. • JA 3-5500





Conversion to
NYLON-GEAR
BY SMALL-LOT
MOLDING PROCESS
ACTUAL SIZE ACTUAL SIZE
SAVES 26¢ PER UNIT

This Zytel 101 Nylon Beveled Gear replaced a machined gear that formerly cost 59¢ each. After the initial tooling costs we die-molded it in one operation by our special injection process at 33¢ each.

COST ANALYSIS:
Tooling, set-up and first 100 pieces, including material and trimming......... $286.00
Additional 100 lots: $33.00

In addition to a cheaper piece price and equal wearing qualities, the Nylon Gear proved rustproof, noiseless, required no oiling and weighed less.

Let us quote on your Short-Run Plastic Moldings. We will gladly submit quotations without obligation.

DAYTON ROGERS
Manufacturing Company
MINNEAPOLIS 7X, MINNESOTA

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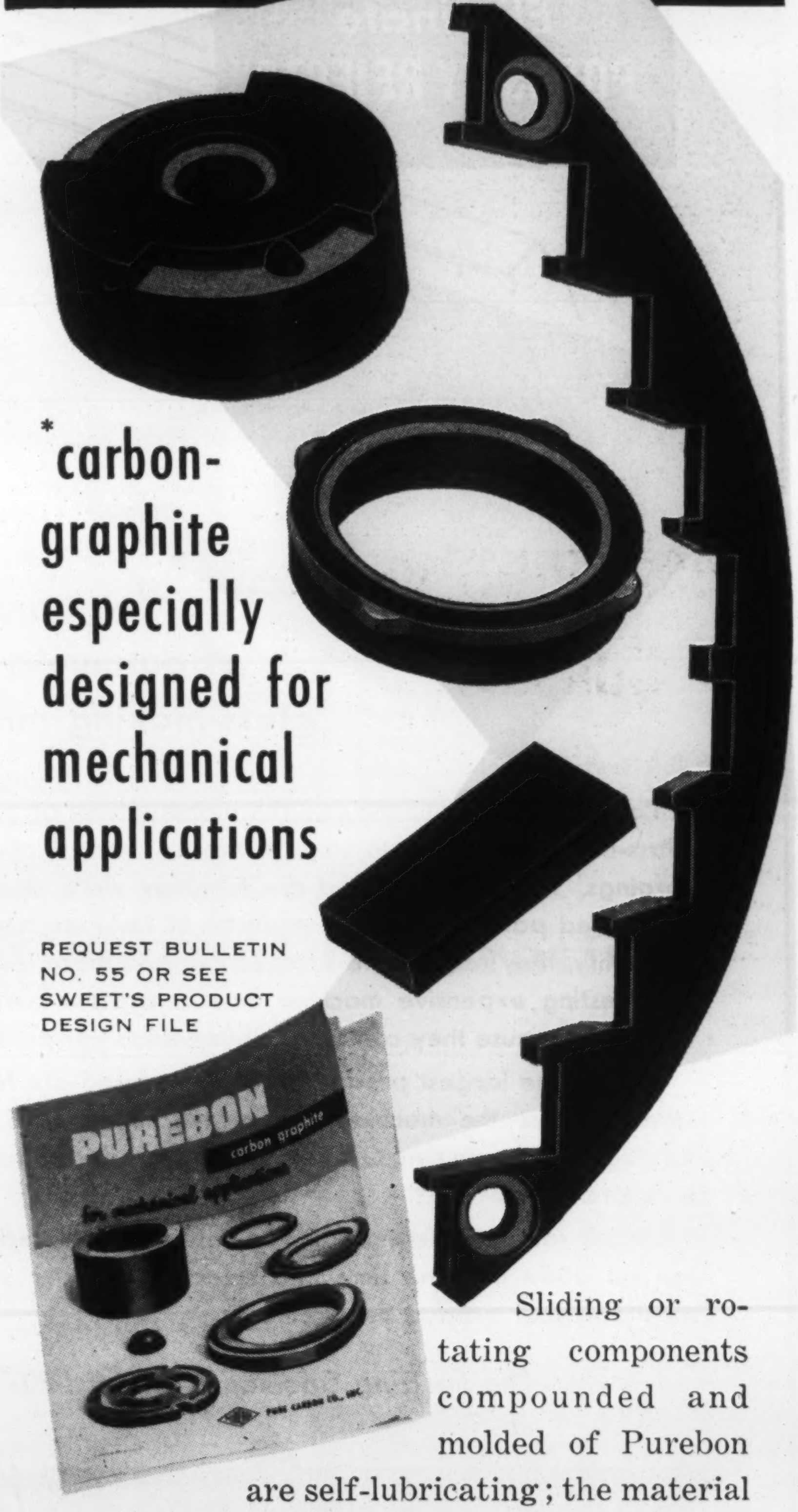
*PUREBON
SELF LUBRICATING
LOW FRICTION
STABLE AT HIGH TEMPERATURES



*carbon-graphite especially designed for mechanical applications

REQUEST BULLETIN NO. 55 OR SEE SWEET'S PRODUCT DESIGN FILE

Sliding or rotating components compounded and molded of Purebon are self-lubricating; the material is unusually stable at high temperatures. It is readily machinable, chemically inert, light weight, low cost when moldable to size. Send prints or parts for prompt quotation.

PURE CARBON CO., INC.
447 HALL AVE., ST. MARYS, PA.

For more information, turn to Reader Service card, circle No. 362

700 PARK CLOSED-DIE FORGINGS

. . . Wt. 2750 Lbs. Ea.

SAVE
MACHINING TIME
Eliminate
"POROSITY REJECTS"
for manufacturer
of automotive
glass-making machinery

A Park sales engineer showed this manufacturer of an automated glass-making line how to save money by using large, closed-die forgings. These Park closed-die forgings were closer to being completed parts—needed a minimum of final machining. Uniform in quality, they required less inspection. And there was no danger of investing expensive machine time in parts—then have them rejected because they contained "blow-holes" or porosity defects.

One of the largest production runs of closed-die forgings ever scheduled for the machine tool or machinery field, these 700 forgings, each weighing 2750 lbs., were produced in Park's shops in record time.

Let our sales engineers show you how a Park closed-die forging can cut down machine time and rejects—increase strength and safety on your product requirements.

Die Forging Specialists Since 1907

THE PARK DROP FORGE CO.

775 EAST 79TH ST. • CLEVELAND 3, OHIO

Carbon, Alloy, Heat-Resistant Alloy, and Stainless Steel Closed-Die Forgings from 5 lbs. to 5000 lbs.

For more information, turn to Reader Service card, circle No. 530

is available in small quantities at \$19.00 per lb. Large scale commercial shipments are expected to be made early in 1959.

Water-base paints—A reduction of approximately 1½¢ per lb in the delivered price of tank car lots of styrene-butadiene latexes has been announced by Dow Chemical Co. These latexes, the high styrene type, are used in 85% of the water-thinned paint manufactured today.

Also of interest is the fact that the volume of acrylic latex paint used in the United States increased by two-thirds during 1956, and the number of paint companies producing acrylic paints increased from 300 to approximately 450. First quarter use in 1957 was 35% higher than usage in the similar period in 1956.

Silicon—A price decrease of 1½¢ per lb for all grades of silicon metal has been announced by Electro Metallurgical Co., div. of Union Carbide Corp. Price reduction amounts to about 7%.

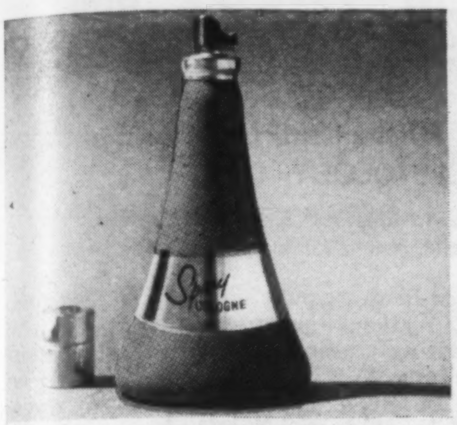
Polystyrene—A reduction of 5¢ per lb for powder and 7¢ per lb for pellets has been announced by Marbon Chemical Co. for its Cycolac polystyrene resin. New prices are: 53¢ per lb for powder, 58¢ per lb for pellets.

Dow Chemical Co. has reduced its price of general purpose molding grade crystal polystyrene shipped in bags by 1½¢ per lb. Colored polystyrene in bags has been reduced ½¢ per lb. This brings the quantity price of Dow's crystal polystyrene down to 26¢ per lb.

Lithium—According to Marshal Sittig, president and managing director, American Lithium Institute, Inc., American industry will consume over *one* million pounds of lithium metal annually by 1970.

Columbium — Shieldalloy Corp. has announced a new low price for metallic columbium: \$16.00 per lb

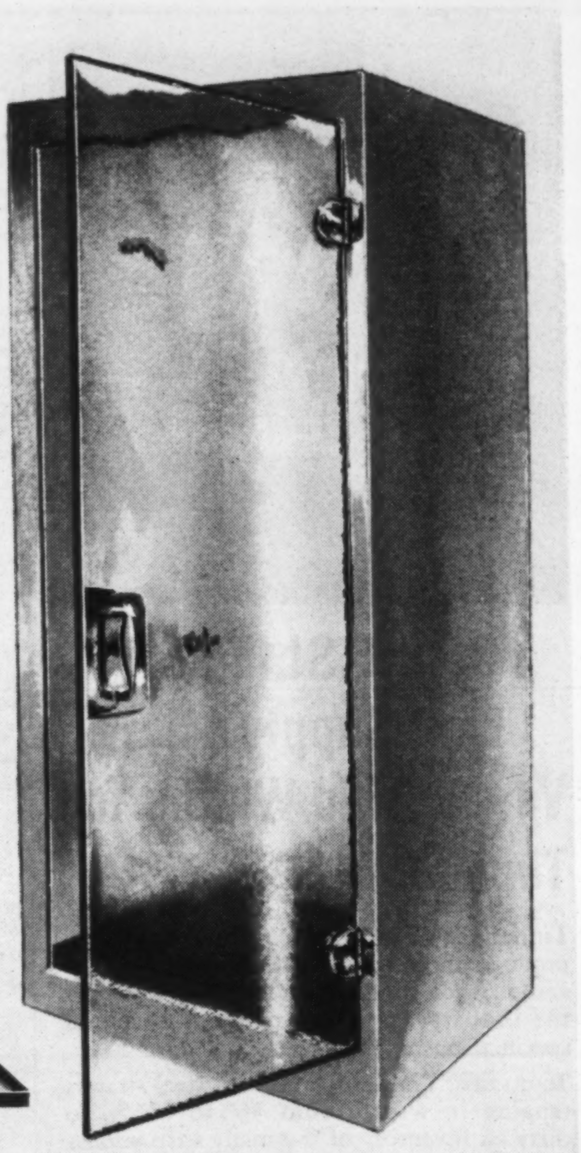
NEW WAY TO UPGRADE YOUR PRODUCTS: VINYL COATINGS



Cosmetic bottle with a thick, smooth coating. Stylish and safe —even for aerosols. Glamorous and shatterproof with a single dip into a vinyl dispersion.

For high-styled "leather-covered" gift bottles for merchandising liquors . . . and breakage-protection for glass chemical-containers . . .

For friction sleeves to control rattles on glass shelving and to eliminate need for polishing edges . . .



For the tight fitting of shower-stall doors.

Thick, tough, protective and decorative coatings for glass

Amazing to the eye, pleasant to the touch—these leather-like coatings offer you new ways to merchandise with glass. These coatings add new beauty, longer life and safety to dozens of market-building applications—for household, workshop, factory.

You can apply the coatings simply by dipping the glass into specially formulated vinyl dispersions. You can make the coating up to 1/16" (60 mils) thick. Preheating the glass controls the thickness. Then a short heat-cure "sets" the plastic in a permanent bond to the glass.

The leather-like coating can range from firm and hard to soft and rubbery. The color? Your choice. The possibilities? Virtually untapped. Coating glass with vinyl is a new industrial art—a starting point waiting for your development.

Write today for sources of vinyl in liquid form for coating glass, metal, or wood.

Monsanto manufactures a wide variety of plasticizers and Opalon® resins for formulators of these high-quality vinyl dispersions.

MONSANTO ®

Where Creative Chemistry Works Wonders for You

Organic Chemicals Division
MONSANTO CHEMICAL COMPANY
Dept. MMSP-3, St. Louis 1, Missouri

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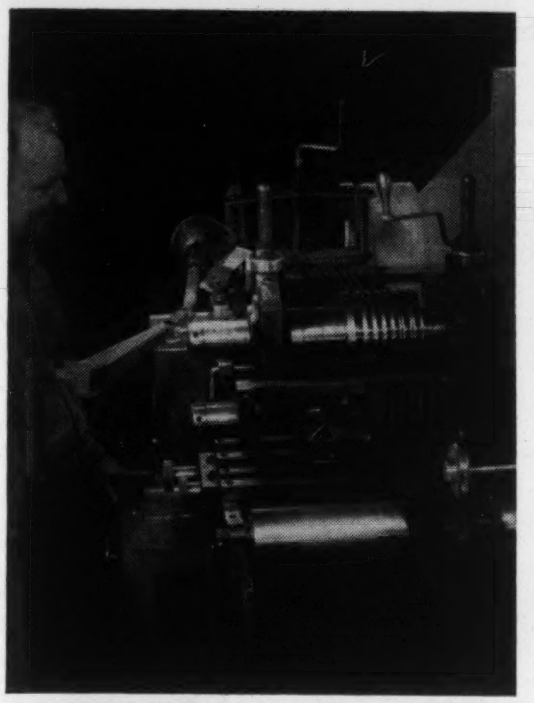

YODER SLITTERS
Supply
Varied Strip Widths for
Tinnerman *Speed Nuts*®

Tinnerman Products, Inc., Cleveland, Ohio, produces more than 10,000 different shapes and sizes of "SPEED NUT" brand fasteners for industry . . . many of them to special specifications.

To do this, Tinnerman uses slit steel strands ranging in width from 1/8" to 7 1/2". To carry an inventory of the many strip widths required to meet normal and unusual demands would be almost impossible.

Tinnerman overcomes these inventory and supply problems by doing their own slitting on two Yoder slitters. This enables them to supply the plant with any strip size required from a relatively small inventory of 6" and 9" width purchased coils. In slitting narrow strands, such as these from small coils, a Yoder slitter may be profitable on a production as low as 25 tons per month.

Here is a fine example of how a small investment in Yoder slitting equipment greatly simplifies and speeds production while effecting important operating economies. The saving made in time alone, reflects in better customer service through faster completion and delivery of finished products.

If your steel strip or sheet slitting requirements are as low as 100 tons per month or even less, a medium size Yoder slitter can be a very profitable investment for you. The Yoder line includes units of every size and capacity . . . of the most advanced engineering design. Send for the Yoder Slitter Book —a comprehensive text on the mechanics and economics of slitters and slitting line operation, with time studies, cost analyses and other valuable data. Write to:

THE YODER COMPANY
5546 Walworth Avenue • Cleveland 2, Ohio

ENGINEERING **YODER** MANUFACTURING **ROTARY SLITTING LINES**

For more information, circle No. 429

in maximum quantities, f.o.b. New Jersey.

Steel—Lukens Steel Co. has started work on a $33 million expansion program aimed at increasing its steel ingot capacity by nearly 25%—from 750,000 to 925,000 tons annually. Rolling capacity of its mills will also be increased by about 40%. Completion of facilities is expected within two years.

Aluminum—Aluminum Co. of America has increased the price of basic aluminum pig by 1¢ per lb., making the price now 26¢ per lb. Price increases amounting to about 4% were also announced for alloy grades of pig and ingot, as well as other products. Reynolds Metals Co. and Kaiser Aluminum & Chemical Sales Corp. are expected to follow suit.

According to the Aluminum Assn., primary aluminum output in the first six months of 1957 was 823,967 tons—less than 4% lower than the all-time high of 860,304 tons produced during the first half of 1956.

Melamine—Barrett Div., Allied Chemical & Dye Corp., has begun a plant expansion aimed at doubling its output of melamine molding compounds. One reason: consumption of melamine for dinnerware was approximately 22% higher in the first half of 1957 than it was in the similar period of 1956, according to the Melamine Council.

Silicon—A price decrease of 1 1/2¢ per lb for all grades of silicon metal has been announced by Electro Metallurgical Co., div. of Union Carbide Corp. Price reduction amounts to about 7%.

A new company formed by W. R. Grace & Co. and Pechiney, a French chemical and metallurgical concern, will produce 20,000 lb per year of high purity elemental silicon and other semiconductors. The plant is scheduled for completion

new WILEY books

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By EARL R. PARKER, University of California

Contains a thorough discussion of the theories and mechanisms of failure, a review of test methods for evaluating relative brittleness, summaries of test results; a discussion of the effects of welding composition variations on notch toughness, and a report of service failures. Prepared for the Ship Structure Committee under the direction of the Committee on Ship Steel, National Research Council.

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3. ENGINEERING PROPERTIES AND APPLICATIONS OF PLASTICS

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Furnishes a clear understanding of the fundamental nature of plastics, their proper utilization and specification. Describes methods for fabrication, as well as the mechanical, electrical, optical, and thermal properties of these materials.

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4. BORON, CALCIUM, COLUMBIUM, and ZIRCONIUM in IRON and STEEL

By R. A. GRANGE, United States Steel Corp.; F. J. SHORTSLEEVE, D. C. HILTY, W. O. BINDER, all of the Electro Metallurgical Co.; G. T. MOTOCK, Olin Mathieson Chemical Corp.; and C. M. OFFENHAUER, the Electro Metallurgical Co.

A concise summary of all the available data on four of the important alloying metals for iron and steel. Complete, accurate information, some of it for the first time in published form. The fourth publication in the Alloys of Iron Research New Monograph Series, Frank T. Sisco, Director.

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Tagged merchandise sells better and stays sold. Your product tag informs consumer and sales clerks about features, care and usage, builds brand identification. It does more and we have facts (see below) to help you help yourself to increased sales. Send for our free guides to better merchandising.

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(Established 1904)

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☐ Send SURVEY "The Effect of Tags on Department Store Sales"
☐ Send "TIPS on TAGS"
☐ Send METL-GLO metallic ink chart
☐ Send Representative to design tag and quote

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Send prints or sample parts, giving production requirements and results you wish to achieve.

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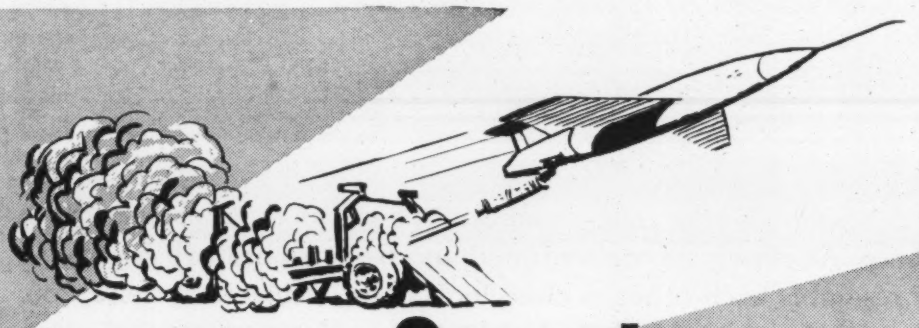

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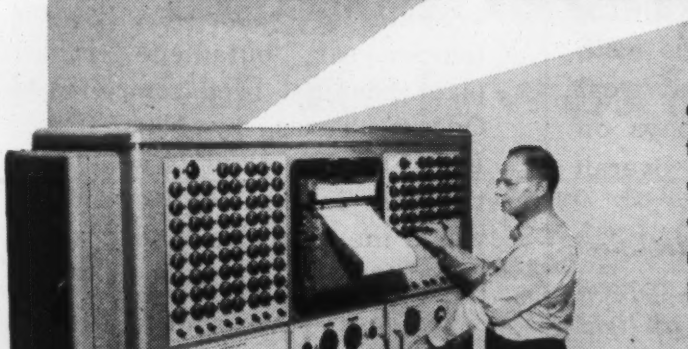

QUANTOMETRIC CONTROL is surer for metals of today and the future. Inquire about our complete, accurate, economical and fast analyses services for Titanium and Zirconium metals and their alloys. Our Spectrographers and Chemists have had many years of experience. Our facilities include the world's largest Quantometer, standardized and calibrated for Titanium and Zirconium Alloys, Steels, Aluminum, Cast Iron and specialized alloys; a most versatile Spectrographic Laboratory; and a complete modern Wet Chemical Laboratory.

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SPECTROCHEMICAL LABORATORIES, INC.
P. O. Box 8781, Pittsburgh 21, Pa.

For more information, turn to Reader Service card, circle No. 373

there IS a difference

Though fingers may look alike, close examination of the fingerprints always finds a difference. As closely as conventional and Rolle laboratory controlled castings may resemble each other, a close look finds a difference there, too.

The difference is born in the Rolle Laboratories. Years of specialization in the sand, permanent mold, shell mold, and investment casting of aluminum and magnesium have resulted in intimate familiarity with the characteristics and peculiarities of each alloy. The difference grows with the quantometer and wet analysis, and physical testing of every single melt. It thrives under the most accurate control of melt, pour, and heat treat temperatures modern foundry instruments can provide. And it pays off in fewer rejects . . . longer life . . . higher physicals . . . and lower overall casting cost.

If you'd like to learn more about the benefits of Rolle laboratory control first hand, send along your prints for an obligation-free quote. In any case, request your copy of Rolle's 58 page engineering manual with complete data on all light metal casting alloys and hundreds of hints on casting design and specification.

there is a difference in **ROLLE**

laboratory controlled castings

ROLLE MANUFACTURING CO. • Third & Cannon • Lansdale, Pa. • Ulysses 5-1171

For more information, turn to Reader Service card, circle No. 408

by next summer. So far the company has not announced prices.

Acetate film—Du Pont has increased its price for cellulose acetate film 5¢ per lb. The film is used principally in laminations as a base for pressure sensitive and sound recording tape, and in packaging.

Polyethylene—Hercules Powder Co. is now ready to start commercial production of its Ziegler-type high density (low pressure) polyethylene. The company will turn out 30 million pounds per year.

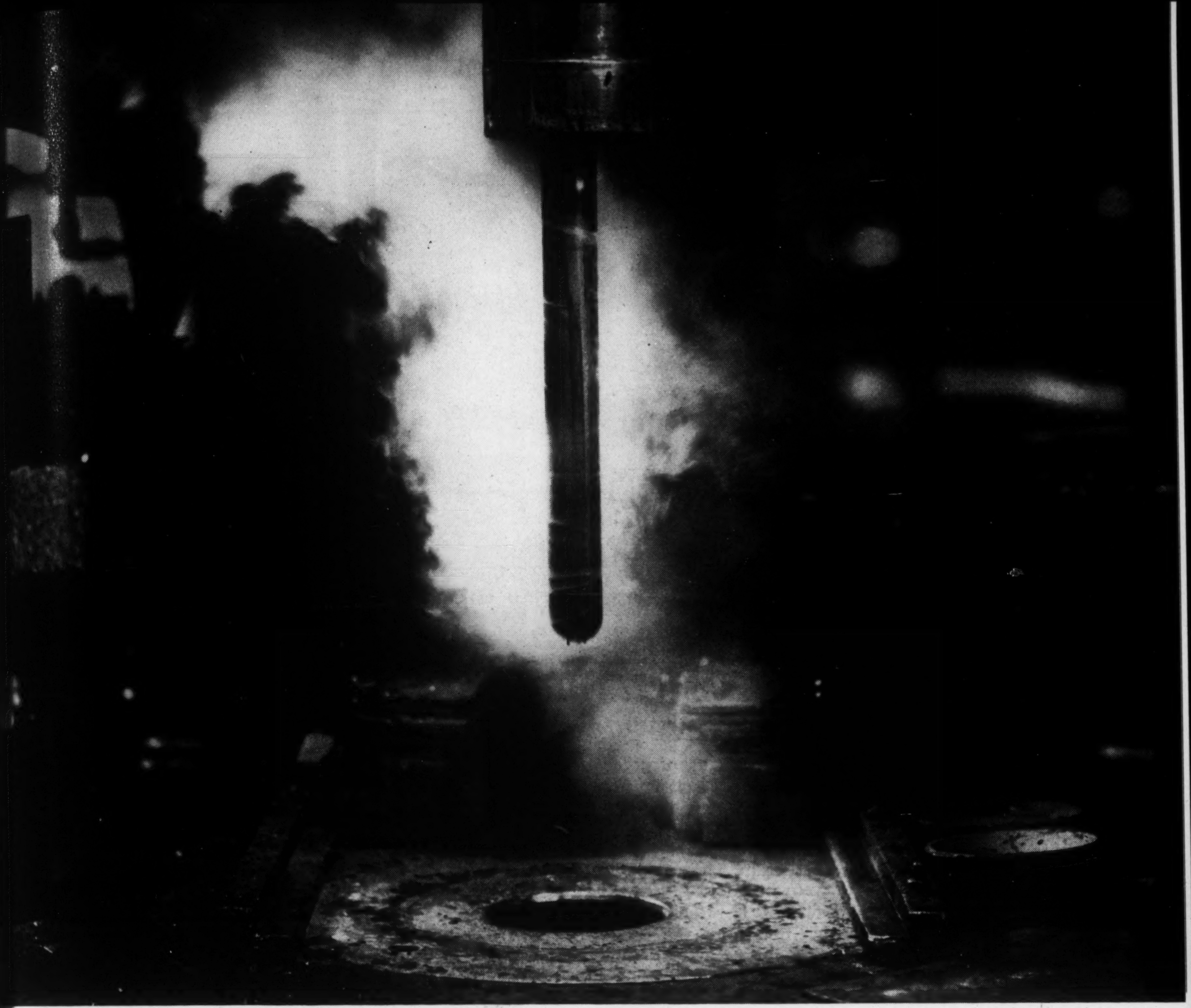
Canadian Industries Ltd., Montreal, announced it will increase its general purpose polyethylene producing capacity to over 40 million pounds per year.

Particle board—The Structural Products Div. of National Starch Products, Inc., will more than double its production of particle board, according to James Dillon, vice president. According to the company, particle board is being viewed as a new design material, and if expansion continues at the present rate, the industry will be producing approximately one billion square feet by 1960. Present annual capacity of the industry is 450 million square feet of ¾-in. board.

Synthetic rubber—A 50,000-ton-per-year butadiene rubber plant has just been completed at Odessa, Texas, by Fluor Corp., Ltd. The new plant is said to be the first integrated operation in which the synthetic rubber is produced from butane at one location.

Isotopes — According to the 1957 Isotope Index, a recently issued report published by Scientific Equipment Co., the supply of isotope-labeled compounds has increased 30% during the last year. Both radioactive and stable isotopes are now available from 53 suppliers, principally in the United States, Canada and Great Britain.

For more information, circle No. 404 ➤



Tough 2½″ diameter mandrel at Rc 44 on 1150 ton brass extrusion press. Scovill Manufacturing Co.

Mandrel of HALCOMB 218 retains toughness and hardness at hot work temperatures...

This mandrel is made of Halcomb 218—a tough, air-hardening hot work steel. Halcomb 218 is suitable for tools like this which require a higher degree of toughness at moderately elevated temperatures than is obtainable with the tungsten types of hot work steels. And Halcomb 218 *retains both* its hardness and strength at these temperatures.

For example, at a hardness of Rc 44, Halcomb 218's Charpy Impact Strength is 33 ft-lbs at 500F. And it will retain this hardness after 1 hour, after 10 hours and even after 100 hours at temperatures up to 900F.

Properties like these cut tooling costs. The mandrel shown above is good for 1200 pushes, for example, and even then all it needs, usually, is repolishing before being used again.

Halcomb 218 is particularly useful for all hot work operations on which drastic coolants are used. It even resists breaking very successfully when water cooled in operation. If these sound like advantages you can use, call your local Crucible representative for more complete data. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

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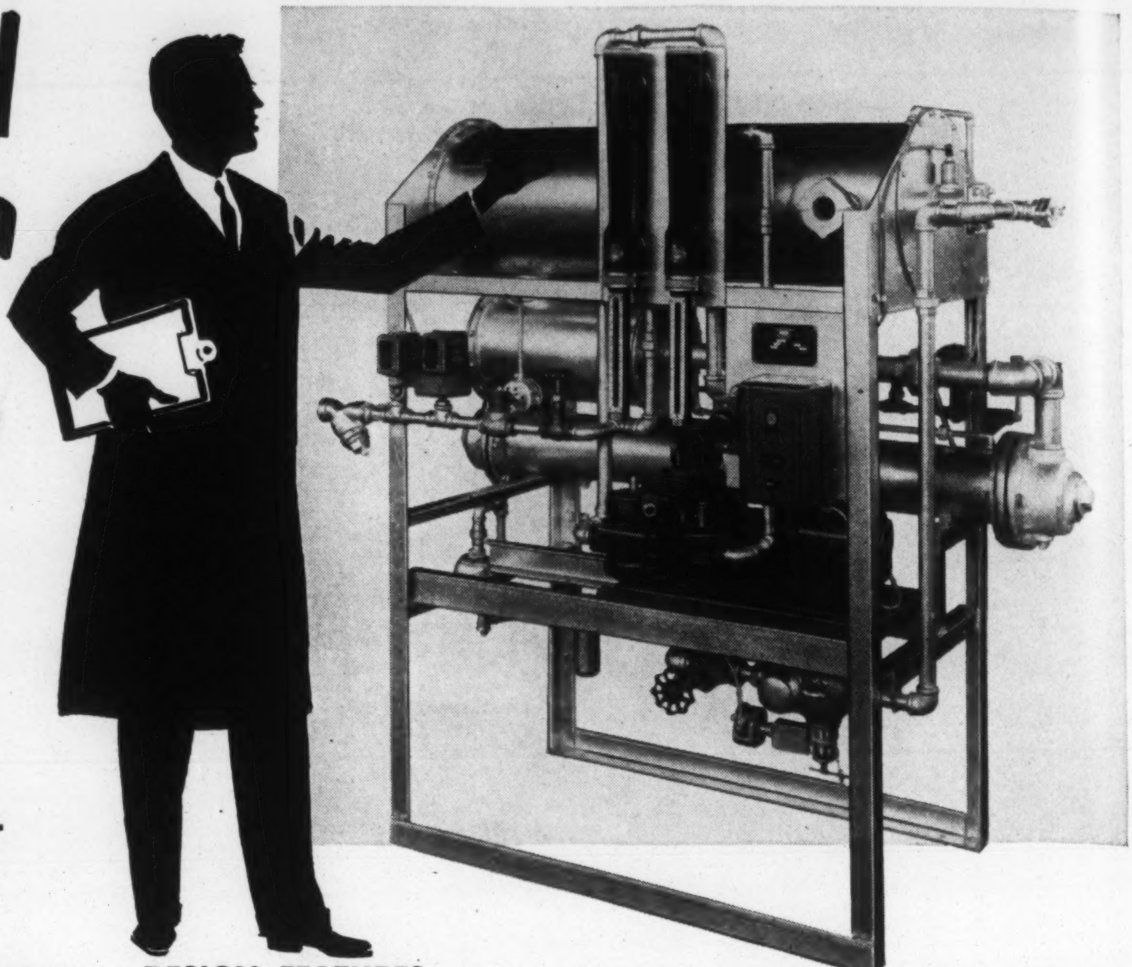
CHOOSE HAYES PROTECTIVE ATMOSPHERES!

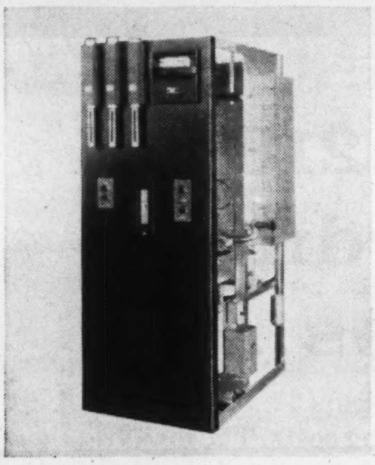
Proper atmosphere equipment increases production, improves product quality, and makes your processing more economical!!



HAYES Type G Exothermic Generator . . . DESIGN FEATURES

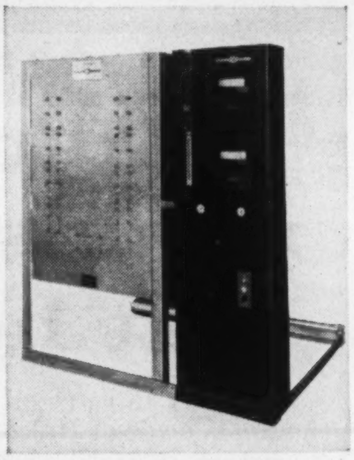
For conveyor or pusher type furnaces requiring protective atmospheres of an oxidizing or medium reducing type, the Hayes Type G Exothermic Generator offers many design advantages which include:

- **ELECTRIC IGNITION SYSTEM** for added safety! Simple, effective design, stainless steel construction. Located out of actual combustion chamber to prevent burn out.
- **AUTOMATIC COMBUSTION CONTROL** is obtained by a self-adjusting mixing device which maintains the pre-set combustion ratio thereby eliminating the need for manual regulation of the gas-air valves.
- **HEAT EXCHANGER** designed with easily accessible, straight tubes . . . facilitates cleaning without disassembly.
- **FLOW METERS** give accurate indication of actual, not relative, flow measurement.
- **SPECIAL FEATURE AVAILABLE** to adapt standard model to glass-to-metal sealing applications. Request details.
- **STANDARD SIZES** range from 200 CFH to 4000 CFH. Larger sizes also available.



Hayes Type IGL Endothermic Generator incorporates many of the above design features . . . is ideal for providing protective atmospheres which are not only reducing but are adjustable for carbon potential . . . giving protection to medium or high carbon steel. Provides for the close control of retort temperatures, complete control of gas and air ratio and subsequent atmosphere dew point. Request complete data!

Hayes Type AD Ammonia Dissociators are now available at rated capacities up to 5000 CFH . . . producing a comparatively inexpensive hydrogen-nitrogen atmosphere of extreme purity and very low dew point. Such atmospheres are required for heat treatment of stainless steels and are extremely helpful in providing protection where exothermic atmospheres are not adequate.



Hayes Molecu-Dryer, a new concept in air and gas drying, effectively removes moisture down to a dew point of —100°F. Request complete data.

Hayes Service Engineers assist customers in starting their equipment and adjusting it to meet their exact requirements. Whatever your heat treating problem, bring it to the unique Hayes Laboratory for recommendations!!

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Request Bulletin 256 for complete information on Hayes Atmosphere Equipment. Let us show you how to improve your product, increase output, and reduce unit costs . . . with RESULTS GUARANTEED! Check literature desired on any of the following procedures . . . write today!

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- ☐ **Stainless Steel Heat Treating**
- ☐ **Sintering**
- ☐ **Copper Brazing and Soldering**
- ☐ **Lead Pot Hardening and Tempering**

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Company..........

Street..........

City and State..........

For more information, turn to Reader Service card, circle No. 547

News OF INDUSTRY

Tape runs machine—The first production model of a "numerically controlled" jig borer has been sent by Pratt & Whitney Co., Inc., to Pratt & Whitney Aircraft Co.

The 12-ton machine (see photo) operates automatically from information fed to it by a punched paper tape. This system of numerical control is believed to be the nearest approach yet devised to complete automation of machine tools. The machine will be used to turn out parts on the company's aircraft production lines.

Castings Sessions Set by ASME

Five sessions dealing with many phases of castings will occupy a major portion of the 1957 fall meeting of the American Society of Mechanical Engineers, to be held Sept 23-25 in Hartford, Conn.

The castings sessions, sponsored by the Metals Engineering Div. of ASME, will include papers on a wide range of subjects, from magnesium castings to elevated temperature properties of alloy steel castings. In all, 15 papers on castings will be delivered.

First Industry-Owned Nuclear Testing Reactor

The world's first industry-owned nuclear testing reactor is being built by Westinghouse Electric Corp. According to Charles H. Weaver, vice president, the reactor will operate in the range of 20,000 kw, or above, and will be used primarily for irradiation testing of fuel and materials for power reactor use and for investigating the effects of radiation on materials in general. It may also be used for limited production of radioisotopes.

The reactor will be housed in a building consisting of a vapor shell 72 ft high by 70 ft in dia placed above a concrete basement 32 ft deep. Uranium enriched by isotope U-235 will be used as fuel. The reactor will be loaded with approximately 60 fuel elements.

Research Program Aims for Pure Metals

A long range research and development program aimed at developing commercially feasible methods of producing chromium, columbium, molybdenum, tantalum, tungsten, titanium, zirconium and hafnium in high degrees of purity has been initiated by Metal & Thermit Corp.

According to H. E. Martin, president, research will be concerned with three principal areas of metal reduction: chemical-metallurgical methods such as those used in producing columbi-

STRAITS TIN REPORT

MALAYAN TIN BUREAU

New developments in the production, marketing and uses of tin

A number of new tin-zirconium alloys developed for use in the constructional elements of nuclear power plants have been patented by the U.S. Atomic Energy Commission. These alloys, containing from 1.8% to 4.5% tin and between 0.3% and 3.3% molybdenum, are said to have high tensile strength at elevated temperatures and excellent corrosion resistance.

* * *

A new group of alloys containing titanium, copper, aluminum and tin are said to react to heat treatment very much like steel. They are strong and ductile at temperatures up to 1000°F. and should have important applications in a variety of industries.

August 31 was Merdeka (Independence) Day in the Federation of Malaya. It then became a new self-governing nation in the British Commonwealth. The Chief Minister, Tengku Abdul Rahman, who proclaimed the Federation's independence, had previously declared that a primary concern of the Government is the well-being of the tin-mining industry.

Tin plating large engineering components—a problem for years—for the first time now has a commercially practical solution. "Dalic" plating brings the anode and the electrolyte to the workpiece, instead of vice versa. There are further advantages. The tin film deposited is finer grained. Deposition is both speedy and controllable to precise time limits.

* * *

Continued experiments in bonding aluminum-tin bearing alloys to steel have brought greater improvements. By hard rolling the aluminum-tin so that its hardness is close to that of soft mild steel, the alloy can be rolled directly onto steel without aluminizing the steel first. This cuts out several manufacturing steps, with resultant savings.

Ask us to send you TIN NEWS, a monthly letter. It will keep you posted on tin supply, prices, new uses and applications.

The Malayan Tin Bureau
Dept. 24J, 1028 Connecticut Ave., Washington 6, D.C.

For more information, circle No. 501

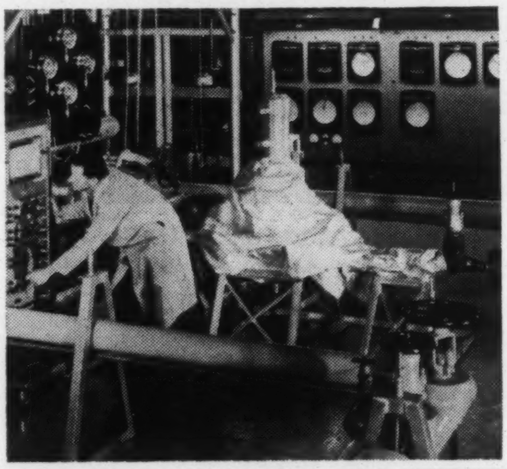
News OF INDUSTRY

um and titanium; electrochemical methods such as those used in making aluminum and magnesium; and the aluminothermic process presently being used by Metal & Thermit to produce chromium and various ferro-alloys.

Colleges and Industry Hold Combined Classes

Western Electric Co., in cooperation with a number of leading universities, has started a program of graduate education for its engineers. According to Timothy E. Shea, vice president, the new program is equivalent in cost and administrative effort to the establishment of a new engineering school of 1000 full-time students.

The educational activities are being conducted on college campuses and in three specially



Stainless test loop—Shown above is some of the equipment used to test atomic reactor coolant valves in Crane Co.'s new testing facility. An important part of this equipment (under an insulating blanket in photo) is a hot test loop made of stainless steel piping. The test loop is actually two separate high pressure, high temperature piping loops. The main loop is connected to the inlet and outlet valve under test and a secondary actuator loop is connected to a valve cylinder to open and close the valve under test.

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For more information, circle No. 367

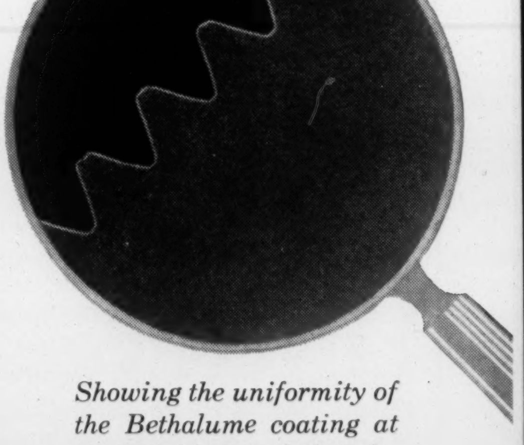
Better Protection Against Corrosion

Fasteners stay on the job for longer periods of time, and in virtually all kinds of atmosphere, when protected against corrosion with Bethalume—Bethlehem's hot-dip coating of pure aluminum.

The Bethalume coating resists corrosion for long periods because it is vastly superior to other types of hot-dip coatings. The Bethalume coating is applied to the base steel by a special technique, providing a corrosion-resistant surface which is unusually uniform over the entire area of the article. As a result, threads are cleaner and sharper than is the case with other hot-dip coatings.

Because of its uniformity, plus the superior corrosion resistance of aluminum, the Bethalume coating has the ability to provide exceptional service just about anywhere—even in high-temperature corrosion applications.

Like to look into the service life of Bethalume-coated fasteners in corrosive atmospheres? If so, just drop a line to the nearest Bethlehem sales office.



Showing the uniformity of the Bethalume coating at root and crest of threads.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

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New Things Are Happening With Graphite

• Do you know that a graphite material of construction is available which is impermeable and is unaffected by practically all corrosives (even chlorine) at *any temperature?* . . . or that another carbon-graphite material possesses a hardness as great as that of glass?

• These outstanding graphite materials are only two of the special formulations developed by Graphite Specialties Corporation, who regularly produce graphite components with special properties of density, purity, strength, permeability, chemical resistance, machining characteristics, etc.

• Graphite Specialties Corporation can produce graphite sufficiently pure for moderating nuclear reactors; or with required properties to provide an exceptionally low erosion rate in rocker nozzles; or with corrosion resistance values to permit use with chlorine at *any* temperature. In addition, other special types are available for crucibles for transistor crystal growth, difficult metallurgical and chemical applications, as well as for mechanical equipment component parts.

• Most types of graphite can be furnished in rod, tube, sheet and block form, or can be molded or produced in special extrusion shapes, or can be machined to close tolerances.

• Write today for information relating to your specific requirements to Graphite Specialties Corporation, 64th Street at Pine Avenue, Niagara Falls, New York.

For more information, circle No. 425

equipped centers in New York, Chicago and Winston-Salem. Each of these centers will include laboratories, libraries, study halls, classrooms and related facilities. Presently six universities are cooperating in the program: New York University, Northwestern, Illinois Institute of Technology, Cornell, Duke and North Carolina State.

Engineers

John Grotzinger, Goodyear Tire & Rubber Co., has been elected to the grade of Fellow in the American Institute of Electrical Engineers.

Allan D. Blackledge has been promoted to assistant manager of Cameron Iron Works, Inc.

Dr. Marion B. Geiger has been appointed director, general development, Hooker Electrochemical Co.

B. V. Edmunds is now works manager, Quaker Rubber Div., and **Edgar G. Platt** general works manager, Refractories Div., H. K. Porter Co. **Ralph R. Rose** has been appointed manager, Basic Refractories Project.

Henry Present has been appointed director of engineering and metallurgy, Jelrus Precision Casting Corp.

Arnold L. Rustay is now technical director and **Marion E. Cieslicki** is director of research at Wyman-Gordon Co.'s Eastern Div. Expansion of the research and development departments also moves **Chester J. Orciuch** to metallurgical manager and **Carl G. Bergstrom** to chief metallurgist.

E. A. Hoffman has been selected for the position of manager, industrial analysis, Research and Development Dept., La Salle Steel Co.

Andrew G. Duzsik has joined Borden Co., Chemical Div., as manager of manufacturing operations in the Resinite Dept.

C. C. Carroll has been named research coordinator, United States Radium Corp. **H. A. Vaughan** suc-

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SHORT-RUN STAMPINGS may be your answer

• For Cutting Costs
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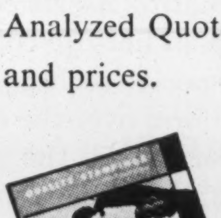
of the cost of conventional tooling methods with Federal's "Controlled Tolerance" short run stampings. Meet time and cost factors with accurate, quality stampings of any material up to 10"x14"x¼" thick . . . any quantity from 2 pieces to 10,000. Send your print, sketch or part for a Federal Analyzed Quotation. Prompt service and prices.



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Tells where and how you can save money using Short Run Stampings. Gives design tips that reduce stamping costs. Write for catalog 201 today.

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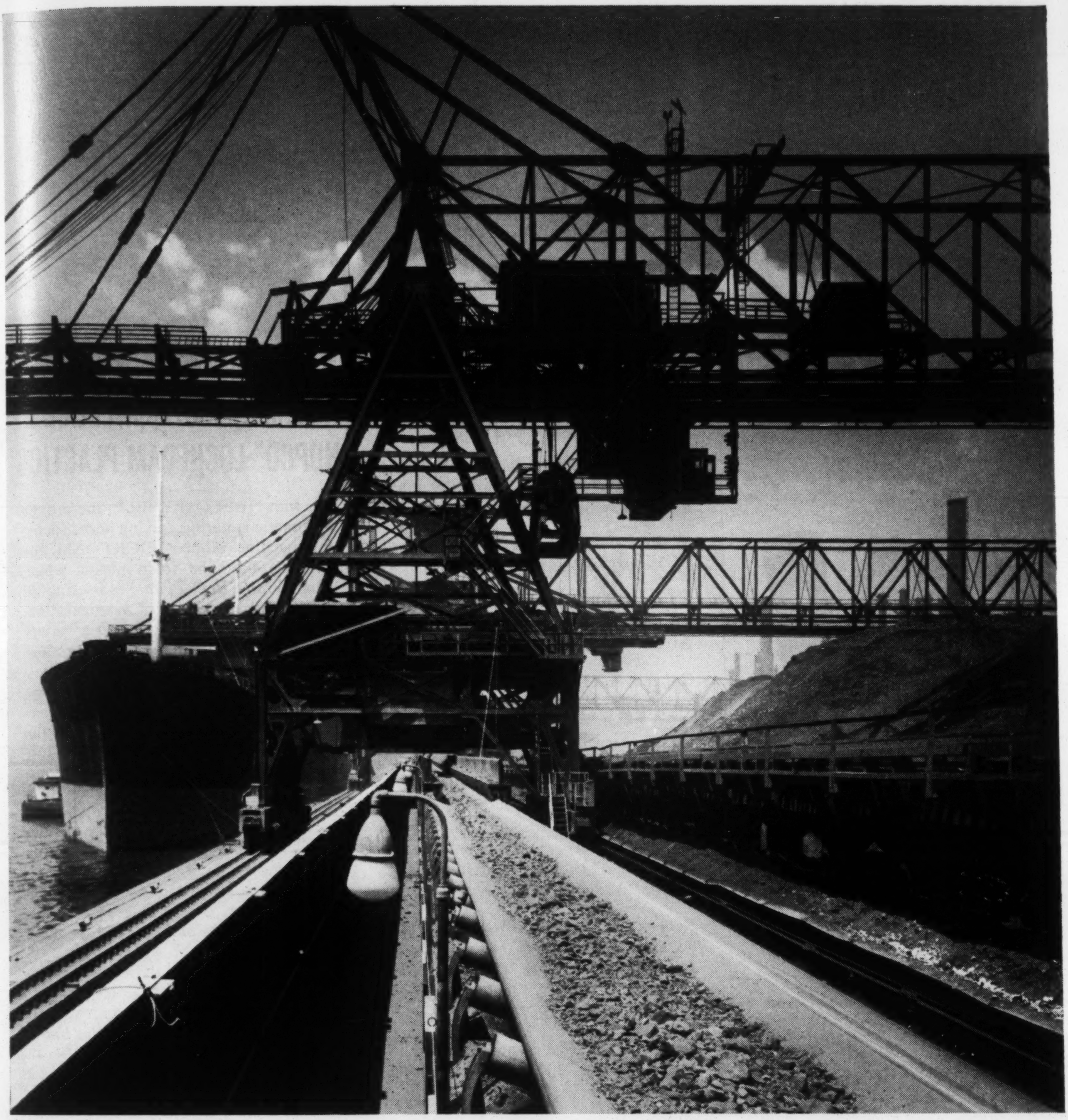

AVISCO® RAYON IN BELTS BY GOODYEAR ADDS TOUGH, TROUGHABLE, FLEXIBLE LONG LIFE

Best way to move 6200 tons of iron ore every hour, night and day, over 1200 feet? One of America's major steel mills selected conveyor belt by Goodyear, with Avisco rayon as its rugged backbone.

Avisco rayon helps to make belts *tough. Troughable. Flexible*—without stretching. And since Avisco rayon pound for pound is strong as steel, belts can be lighter as well. With fewer plies, they're easy to fabricate, easy to work with. Experience in thousands of applications proves their long life. Yet the cost of this reinforcing yarn is low.

Whether you're a fabricator or a user of products that require reinforcement, Avisco rayon can help. You'll want all the facts. Write American Viscose Corporation, 350 Fifth Avenue, New York 1, N. Y.

American Viscose Corporation, 350 Fifth Avenue, New York 1, N. Y.

AVISCO
RAYON®

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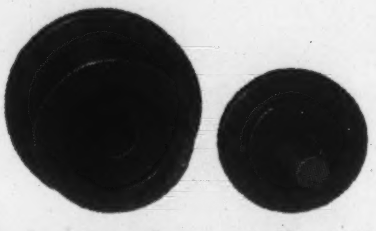
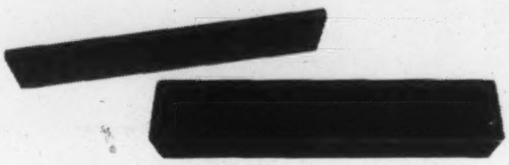
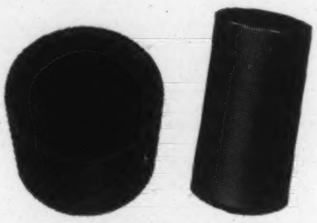
SEEKING THE IDEAL MATERIAL FOR...



• Molds for powder metallurgy?



• Sintering boats?



• Crucibles, jigs, plates?
• Similar hot applications?

HERE'S YOUR ANSWER

Speer carbon and graphite parts are not wetted by molten metals. They hold their shape with no warping, regardless of temperature. They have high heat transfer and will not break down under severe thermal shocks...will not crack or split... are chemically inert.

Easily machined or fabricated, Speer carbon and graphite parts can be provided in almost any size and shape to your *exact* dimensional tolerances. If you have a design problem involving high temperatures, examine the advantages—and economies of Speer Carbon. Speer's knowledge and experience is yours for the asking—mail the coupon today for further details.

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Please send information on carbon for use in
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Title________________
Company________________
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City________ Zone________ State________

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News OF INDUSTRY

ceeds Carroll as plant manager of the Bloomsburg, Pa. plant.

Leonard N. Goodell has been named manager of electrical products and **Fenton L. Tippett** manager of mechanical products, Sunnyvale Div., Westinghouse Electric Corp.

Clarence C. Smith has been appointed director of engineering, Tranter Mfg., Inc.

Richard Schiewetz has advanced to manager of the new Trane Co. plant at Clarksville, Tenn.

Walter H. Sieger is now president of Revere Corp. of America.

Edgar Schmued has been elected to the executive committee, Northrop Aircraft, Inc.

Robert A. Lebowitz has been advanced to manager of manufacturing, Polytechnic Research & Development Co., Inc.

Robert P. Hindman and **William R. Gealey** have been named assistant general superintendents, Armco plant, and **Leroy G. Greenert** superintendent of the rolling dept., Butler Works, Armco Steel Corp.

Robert A. Erskine has been appointed chief engineer, Industrial Dept., and **Carl E. Gunther** chief engineer, Marine and Ordnance Dept., Vickers, Inc.

Dr. Robert F. Rea is now director of engineering, Diamonite Products Mfg. Co.

Prof. William H. Graves has been elected vice president, American Forging & Socket Co. He succeeds the late Frederick C. Anger.

Robert S. Sterrett has joined Matheson Co., Inc., as manager of its Joliet, Ill., branch.

Anthony Del Duca has been advanced to chief electronics engineer, Process Instruments Div., and **Ernest M. Whitley** has been appointed production engineer, Spinco Div., Beckman Instruments, Inc.

Clyde Bohner has joined the Product Design and Development Div., United States Testing Co., Inc.

(News of Companies on p 262)

NOW POSSIBLE

Assembly-line application of NOPCO® LOCKFOAM PLASTICS

. . . with NOPCOMETER®, the proven automatic metering, mixing and dispensing machine. Nopco LOCKFOAM, the versatile urethane foam plastic which when poured in place shapes itself to fill any cavity regardless of configuration, can now be incorporated into a variety of products on an economical production line basis with the Nopcometer.

The Nopcometer is the answer to the need for accurate, dependable metering, mixing and dispensing of any of the Lockfoam formulations at the production line *automatically . . . and intermittently*. Compact portable design permits easy transfer to any point along the assembly line for manufacture of both small and large units. The illustration above shows the Nopcometer in operation pouring Lockfoam P502 structural panels 2" x 4' x 8' at a rate of 20 lbs. min. An increase of 2400% over patch pouring.

Structural and insulating sandwich panels, trailer truck bodies, freezer cabinets, and encapsulated electronic assemblies are just a few of the products now being produced daily with current Lockfoam formulations.

Lockfoams are formulated to provide any degree of rigidity or flexibility, tensile strength, density, and thermal or electrical properties. And with the Nopcometer manufacturers now have a combination that opens unlimited possibilities for new manufacturing techniques . . . new product designs . . . and vastly better product performance. Both are now available for large scale volume production requirements. We await your inquiry.

NOPCO
PLASTICS DIVISION
NORTH ARLINGTON, N. J.
Los Angeles, Calif.

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YOLOY "E" IS ON THE JOB

. . . giving greater strength and corrosion-resistance to salt mine cars

These special mine cars operate 1100 feet below ground where repairs and replacements are costly and difficult. Yoloy "E" was chosen for the bodies of these cars because The International Salt Company needs rugged equipment. Equipment that will resist severe corrosion; equipment that is strong and durable but light in weight.

Yoloy "E" steel meets these exacting specifications. Yoloy "E" has a high strength to weight ratio, superior resistance to corrosion, high resistance to shock and fatigue failure, and is easy to weld and fabricate.

Youngstown's complete family of Yoloy steels is available in sheets, plates, bars, shapes, Cold Drawn Bars, and Tubular products. Data sheets on each of the Yoloy family of steels will be sent upon request.

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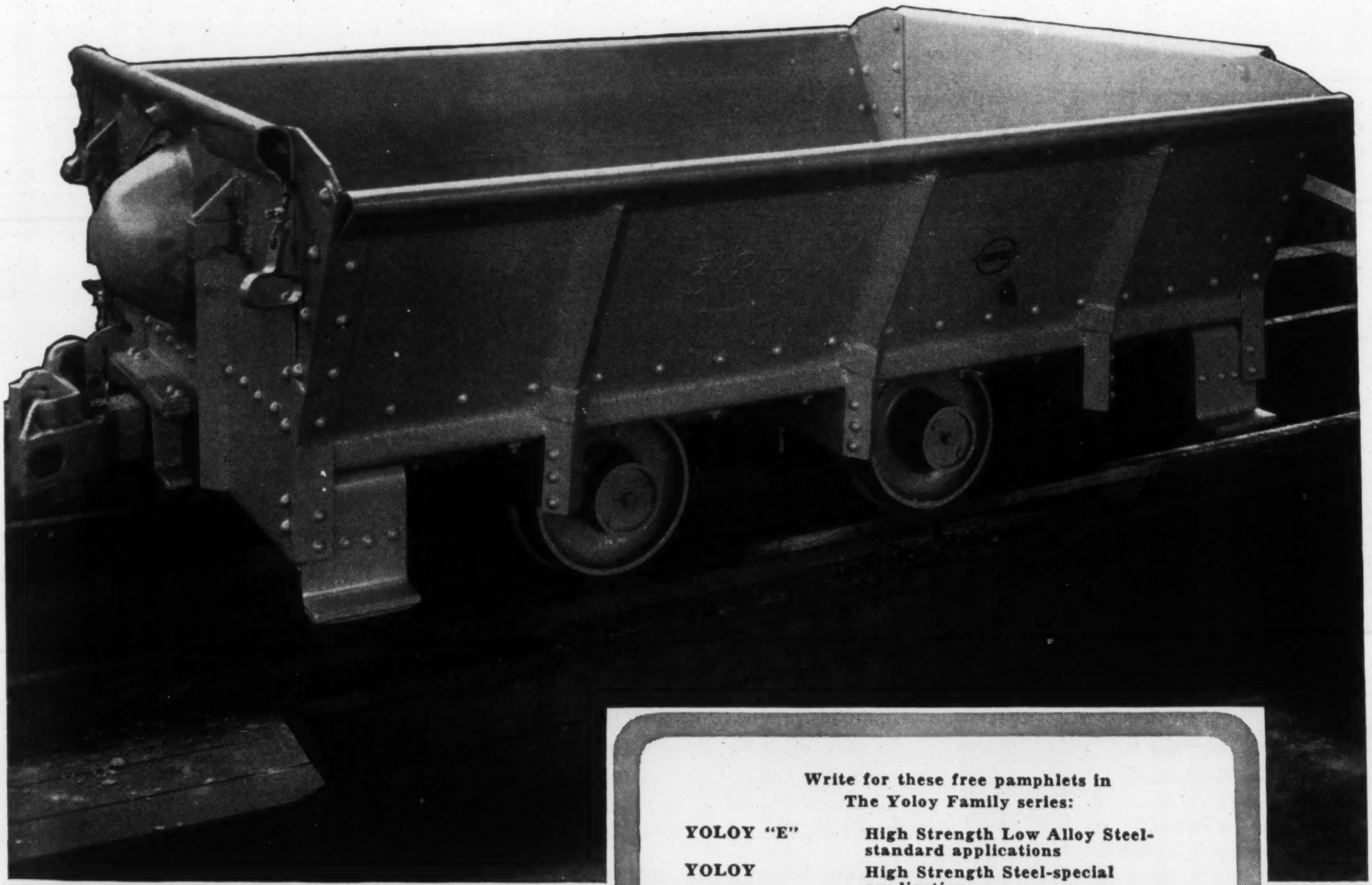

Photograph courtesy of Irwin Foundry and Mine Car Co.

Write for these free pamphlets in The Yoloy Family series:

YOLOY "E"	**High Strength Low Alloy Steel-standard applications**
YOLOY	**High Strength Steel-special applications**
YOLOY "S"	**Higher Strength Steel for increased service life**
YOLOY "C"	**Corrosion Resistant Grade for deep forming**
YOLOY PIPE	**Continuous Weld for corrosion resistant applications**

For more information, turn to Reader Service card, circle No. 435

EF
FURNACES

For Carbonitriding
Carbon Correction
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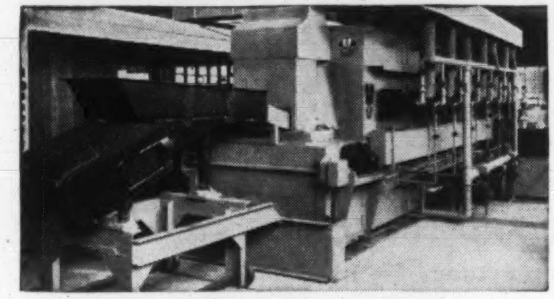
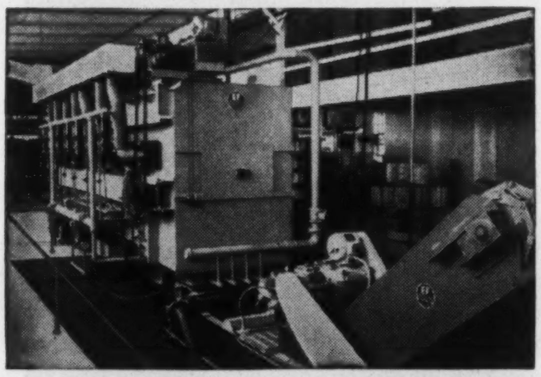
Non-Decarb, Scale-Free
Hardening and other
Processes,
175 to 2000 lbs. per hour



EF Gas Fired Radiant Tube Combination Hardening and Dry Cyaniding Unit Fitted with an Automatic Feeder that Distributes the Parts Evenly on the Chain Belt Conveyor; and a Dual Quench. See View Below.

The EF chain belt conveyor furnace is one of the most satisfactory continuous heating units yet devised for treating small and medium size parts. The material is loaded onto cast link conveyor belt; carried through the furnace; heated uniformly to proper temperature; automatically quenched and discharged. No pans or trays are needed. Hundreds in daily operation prove the dependability and efficiency of our design. Gas, oil or electrically heated. Furnished complete with any desired feeding, discharging or special atmosphere equipment.



The Conveyorized, Partitioned Dual Quench Moves Laterally to Permit either the Complete Oil or the Water Quenching Equipment to be Positioned under the Sealed Furnace Discharge.

BULLETIN No. 461
shows typical installations
of EF Gas-fired, Oil-fired
and Electric Furnaces
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Salem - Ohio
GAS-FIRED, OIL-FIRED AND ELECTRIC FURNACES
FOR ANY PROCESS, PRODUCT OR PRODUCTION

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News OF INDUSTRY

Companies

Bendix Aviation Corp., Scintilla Div., has announced a $5 million plant expansion program scheduled for completion by 1961.

Seaboard Pacific Div. is the new name for Seaboard Coil Spring Div., **Associated Spring Corp.** The new name reflects Seaboard's expansion from limited types of helical springs to the whole range of precision mechanical springs and spring steel products.

American Biltrite Rubber Co., Inc. and **Boston Woven Hose & Rubber** Co. have merged. The latter company will continue to operate as a division of Biltrite.

Dow Corning Corp. is building a silicone products manufacturing plant at Greensboro, N. C. to be known as the Silicone Specialties Div.

Chicago Rawhide Mfg. Co. has established a Special Polymer Section of its Sirvene Div. for the manufacture of molded synthetic parts.

Dana Corp. has activated an Aircraft Dept. which will operate as part of its Pottstown, Pa., Div.

Electronic Communications, Inc. is the new name of **Air Associates, Inc.** The former Aviation Supplies Div. is now the Air Associates Div. of Electronic Communications.

Eldon Fiberglass Mfg. Co., Aircraft Div., has added a 40,000-sq-ft plant to its Los Angeles facilities.

The Martin Co. is the new corporate name of **Glenn L. Martin Co.**

Fairchild Engine and Airplane Corp. has integrated operations of its former Florida Speed Control Div. with the Industrial Products Branch of the Stratos Div. at West Babylon, L. I., N. Y.

Milton Roy Co. is constructing an 18,000-sq-ft plant in St. Petersburg, Fla.

Kaiser Steel Corp. has increased its budget for the current expansion program to a total of $194 million. Ingot capacity will be virtually doubled; principal product increases

TAKE
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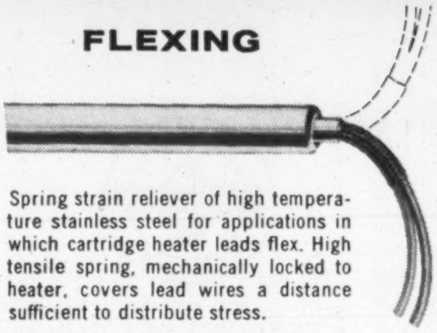
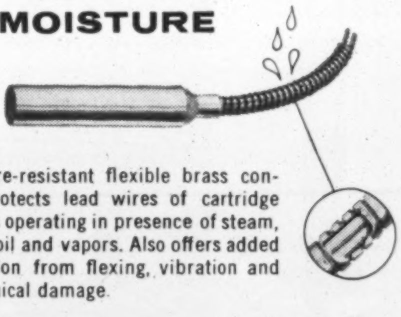
PICK!
Special
Chromalox features
solve 3 spot
heating problems

FLEXING



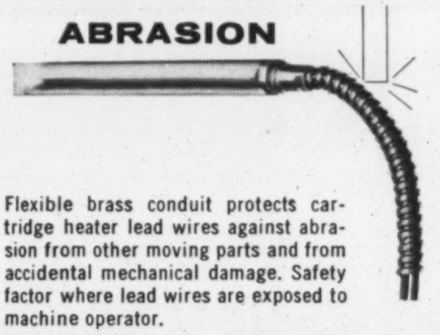
Spring strain reliever of high temperature stainless steel for applications in which cartridge heater leads flex. High tensile spring, mechanically locked to heater, covers lead wires a distance sufficient to distribute stress.

MOISTURE



Moisture-resistant flexible brass conduit protects lead wires of cartridge heaters operating in presence of steam, water, oil and vapors. Also offers added protection from flexing, vibration and mechanical damage.

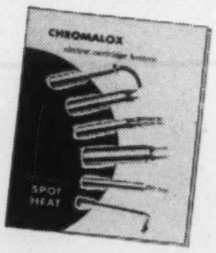
ABRASION



Flexible brass conduit protects cartridge heater lead wires against abrasion from other moving parts and from accidental mechanical damage. Safety factor where lead wires are exposed to machine operator.

FREE BULLETIN!

CHROMALOX
ELECTRIC
CARTRIDGE
HEATERS



Get the full story. Call your Chromalox Representative or write today for Bulletin 850.

C-2101

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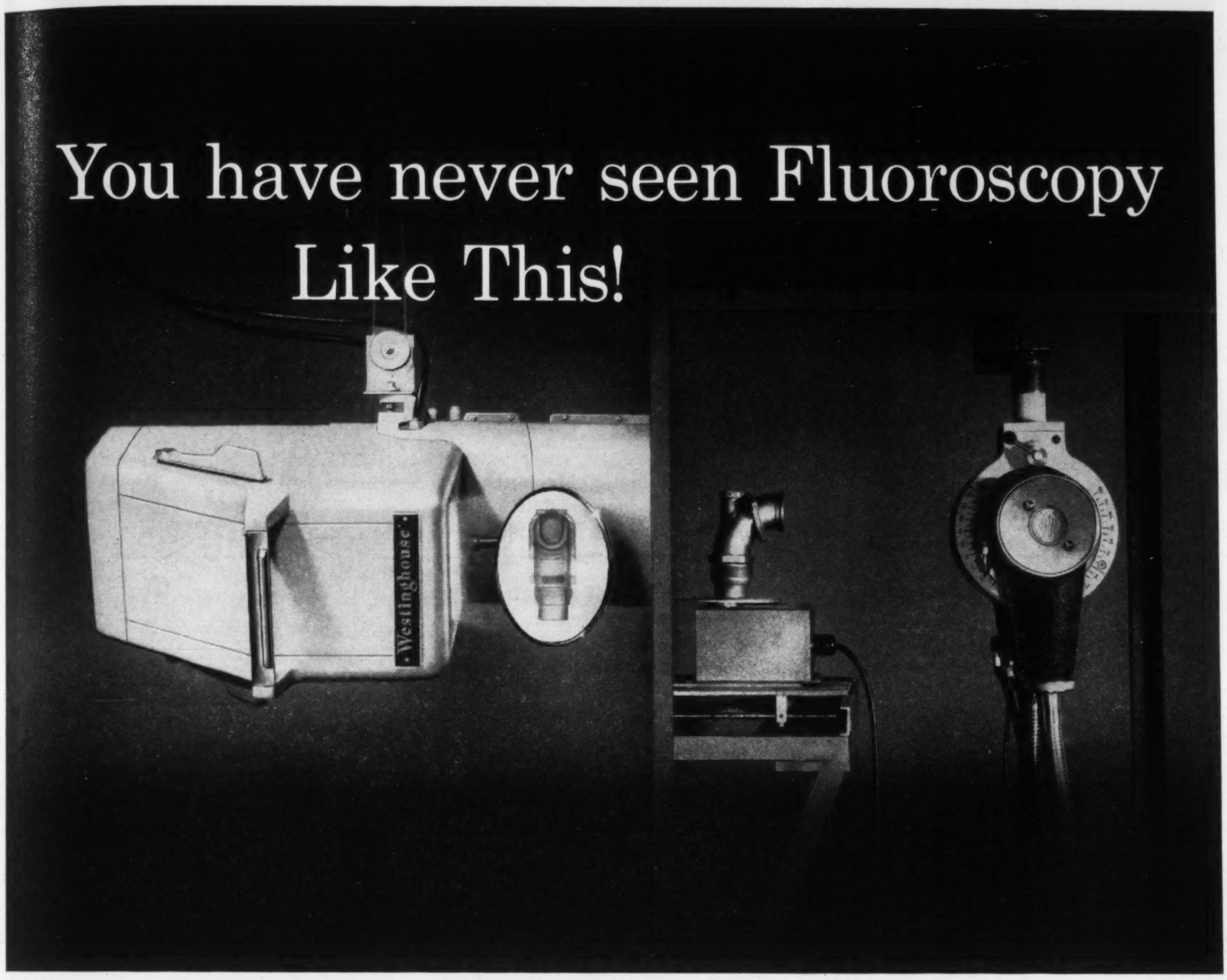
CHROMALOX
FIRST NAME IN ELECTRIC HEAT

For more information, card, circle No. 499



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Now you can "see" through thicker, heavier castings, welds and assemblies with unsurpassed detail, definition and resolution. The Fluorex® Image Intensifier, a product of Westinghouse research and engineering, assures rapid, accurate fluoroscopic inspection; lets you see *more, faster*. Other advantages are daylight viewing (because image is so bright), and a field no larger than the eye can view comfortably. Fluorex can be quickly adapted to your existing X-ray inspection equipment.

Whatever your X-ray inspection problem may be, our staff of Industrial X-ray Engineers can help you solve it with Westinghouse fluoroscopic or radiographic equipment. Write today for complete information: Westinghouse Electric Corporation, X-ray Department, 2519 Wilkens Avenue, Baltimore 3, Maryland. J-08352

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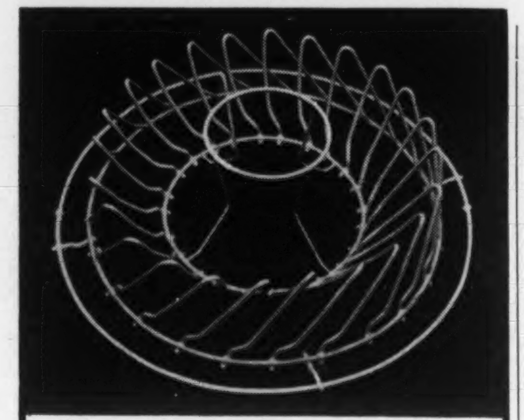
For more information, turn to Reader Service card, circle No. 590



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Looking for a plastisol to give you heavy, uniform coatings without preheating your product before dipping?

Then look to Reynosol — America's fastest growing plastisol for cold-dips. Products such as dish drain baskets, gloves, boots, cable, wire —in fact any product of metal, fabric, wood or paper can be successfully cold dipped with Reynosol.

COLOR	UNLIMITED
WEIGHT	SP. GR. = 1.20
FIRE HAZARD	LITTLE OR NONE
% FILM FORMING	95% to 100%
VISCOSITY	10,000 TO 15,000 CPS.
AGING PROPERTIES	GOOD
COLD PROPERTIES	FLEXIBLE AT 65° F
LIGHT RESISTANCE	GOOD
TYPE OF SURFACE	DRY AND GLOSSY
TENSILE STRENGTH	VERY GOOD
SCUFF RESISTANCE	VERY GOOD
ABRASION RESISTANCE	VERY GOOD
ALKALI RESISTANCE	VERY GOOD
ACID RESISTANCE	VERY GOOD
OIL RESISTANCE	VERY GOOD
HARDNESS	AS HIGH AS 80 (SHORE-A)
COST PER .001 INCH THICKNESS	APPX. $.034 SQ. YD.

Member Vinyl Dispersion Division, SPI

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ANN ARBOR, MICHIGAN

DIVISION OF STUBNITZ GREENE CORP.

For more information, circle No. 578

News OF INDUSTRY

will be in plate, sheet, tinplate and pipe.

Macco Chemical Co. has concluded an agreement to acquire the outstanding capital stock of **Gates Engineering Co.** and **Delaware Valley Steel Works, Inc.** Gates and Delaware will be operated as separate corporations.

National Automatic Machine Tool Co., Inc. has increased its main plant floor space by the addition of a 75 x 530-ft building.

Hydroforming Co. of America, Inc., a new company located in Chicago, uses a custom deep drawing process that operates without conventional costly dies.

San Antonio Chemicals, Inc., a new subsidiary of American Potash & Chemical Corp., will start a comprehensive research program to uncover commercial uses for rubidium and cesium.

Robertshaw-Fulton Controls Co., Flexible Shaft Div., has moved to a new and larger plant in Chatham, N. J.

Ryko Products, Inc. has started production at its new Los Angeles plant.

Societies

Powder Metallurgy Parts Manufacturers Assn. is a new group formed by 21 charter members, custom manufacturers of powder metal bearings and structural parts. The group plans to promote the use and sale of powder metal bearings and parts, develop improved technical standards, and disseminate design information to aid engineers throughout industry. Officers of the new association are: president—Kenneth M. Gleszer, Dixon Sintaloy, Inc.; vice president — William R. Toepletz, Bound Brook Oil-less Bearing Co.; secretary-treasurer—George L. Bachner, Powdered Metal Products Div., Yale and Towne Mfg. Co. Directors are: Smith Bolton, U. S. Graphite Co.; William Toepletz, Bound Brook Oil-less Bearing Co.; Col. G. W. Trichel, Amplex Div., Chrysler Corp.;

Low Tolerance for Strip?

You'll Love Somers Performance

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This is typical of the modern equipment and the careful quality control that enables Somers Brass to produce the one thinstrip job in ten that must meet exacting standards with absolute uniformity.

If you are now using or anticipate the need for thin gauge brass, nickel, copper and alloys with extremely close tolerances write for the Confidential Data Blank. There is no cost or obligation.

Somers THIN STRIP

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108 BALDWIN AVE. WATERBURY, CONN.

For more information, circle No. 484

PREVIOUS PROCEDURE

1 Drill bolt holes in "clip angles."

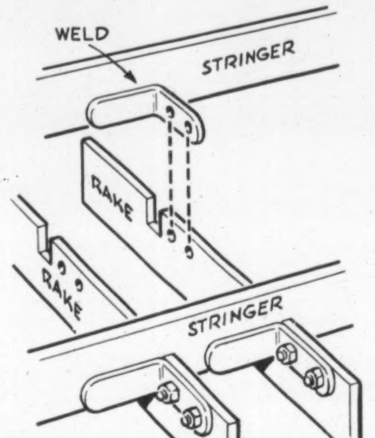
2 Weld clips to stringer.

3 Drill holes in rake blades.

4 Mill stringer slots in rake blades.

5 Bolt rakes to clip angles.

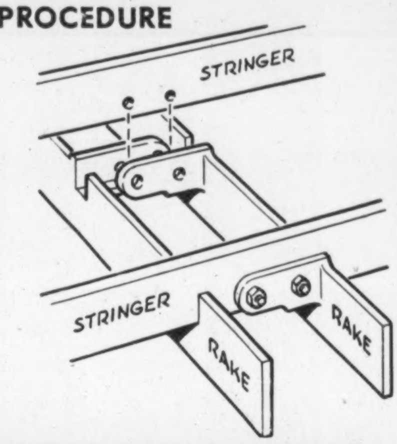
REPEAT FOR EACH BLADE



PRESENT PROCEDURE

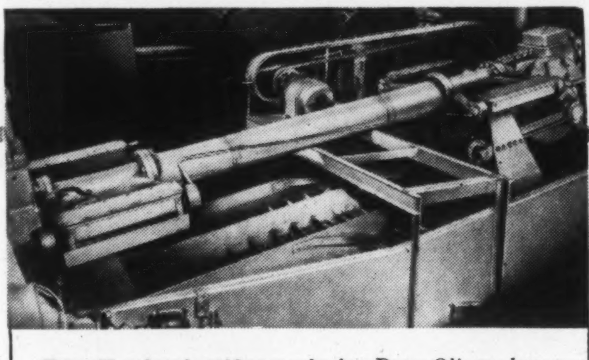
1 Drill bolt holes in stringer.

2 Bolt one-piece castings (complete with holes, slots, and flanges) IN RIGHT- AND LEFT-HAND PAIRS, to stringers.

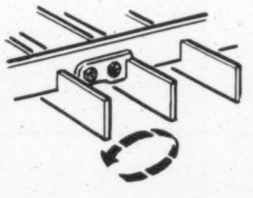


Use of Cooper Alloy close-tolerance shell casting eliminates 3 out of 5 machining operations for Dorr-Oliver rake classifier blades, showing

How to Cut Fabrication Costs with Close-Tolerance Stainless Castings



Type H rake classifier made by Dorr-Oliver Inc., of Stamford, Conn., separates solids in liquid-solid mixtures into two fractions according to particle size. Fine materials overflow with liquid at lower end of inclined tank; larger particles settle to tank bottom, are continuously raked up inclined slope and discharged "over top" Rake blades move in oval track due to motion of rocker head, must be precisely aligned to move settled material up to next rake without either scraping or undue clearance.



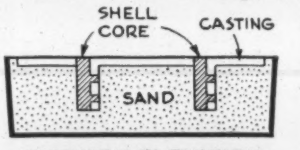
Previous method of attachment of rakes to stringers was by "clip angles" welded to stringers, drilled and bolted to simple flat blades themselves drilled and slotted as shown. Construction was expensive, and often unsatisfactory, in that heat of welding tended to put rakes out of alignment.

In redesigning, Dorr-Oliver decided to eliminate the clip angle as a separate third piece by incorporating it into the blade castings. Original conception was to cast rough slots and holes, then mill and drill them to dimensions. Cooper Alloy, after study of the piece, determined that with close-tolerance plastic shell cores, both bolt holes and stringer slots could be cast directly in the rake blade, without need of further machining. Also, that by using right- and left-hand patterns of rake flanges, *two* rake blades could be bolted to stringers with one set of bolts.

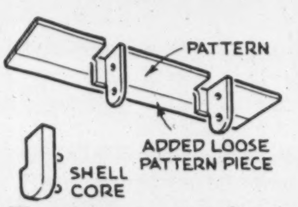
Casting requirements stringent

- Bolted face of each of the upright flanges required a smooth finish (250 A.S.A. Standard).
- 11/16" cored holes had to be smooth, accurate to ±.010", and precisely positioned for proper fitting of parts.
- Stringer slots had to be precisely positioned, accurate in dimensions to ±.025".
- Multiplicity of patterns for different widths of rake blades had to be reduced, for economy.

Casting solutions For the critical flange faces and bolt holes, shell "cake" cores, capable of holding precise dimensions down to ±.010", were prepared. They were inserted and became an integral part of the green-sand molds that formed the less critical outer blade areas.



CUTAWAY ELEVATION: ENTIRE PIECE IN DRAG.



To save cost of a complete new pattern for each rake size, all sizes of rake were designed to have the same blade thickness and flange dimensions. Patterns were then made of the narrowest-width blade in each series, loose pattern pieces being added to increase blade width of the larger rake sizes.

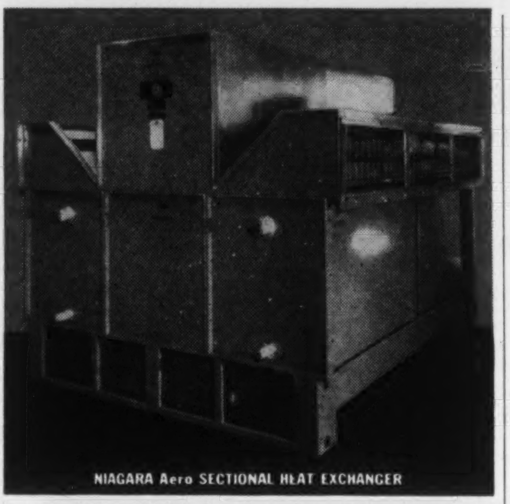
Results –"These rake blades", says Dorr-Oliver, "were used directly as cast, with no additional machining of any kind. Dimensions were precise, surfaces smooth, and finished alignment better than with previous 3-piece welded assembly. New procedure saves time and handling, and has reduced our manufacturing costs on this piece considerably."

Such economy possibilities are available in almost any shape, no matter how simple, or how "cut-and-dried". Cooper Alloy has specialized for 35 years in achieving such uncommon results in close-tolerance stainless steel castings, and can do the same for you.

To check on it, why not take advantage of our Foundry Engrg. Service? Just send us (without obligation) a blueprint or outline of your problem part, for cost analysis, to: Foundry Products Division, COOPER ALLOY CORPORATION, Hillside, N. J.

(Adv.)

For more information, turn to Reader Service card, circle No. 548



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gives close temperature control, saves you

LABOR, Power, Water

● You gain in accurate control of quench bath temperatures and quickly effective capacity to handle initial peak load of heat in quenching. You prevent production set-backs, increase the output of your heat treating department, prevent oil fires, save losses from rejected parts.

Niagara *Aero* Heat Exchangers give you this control in both furnace and induction hardening methods. They prevent both over-heating and over-cooling of the quench bath. Hundreds of heat treaters know they prevent many troubles, constantly improve quality and increase production.

They quickly pay for themselves by saving cooling water coils and extend your quench capacity without extra water or cooling tower.

Use Niagara Aero Heat Exchangers also to cool and control temperature of furnace jackets, induction heaters, welders, wire drawing and extrusion dies, rolls, transformers, engines and all plant water cooling systems.

Write for Bulletins 120 and 132 giving complete information.

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NEW YORK 17, N. Y.

District Engineers in Principal Cities of U. S. and Canada

For more information, circle No. 532

News OF INDUSTRY

Jesse Helsel, Ferro Powdered Metals; John E. Miller, Chicago Powdered Metal Products Co.; G. G. Fellows, American Powdered Metals Inc.; G. L. Bachner, Powdered Metal Products Div., Yale and Towne Mfg. Co.; M. T. Victor, International Powder Metallurgy Corp.; and K. M. Gleszer, Dixon Sintaloy, Inc.

The firm of Hanson and Shea, Inc., 1 Gateway Center, Pittsburgh 22, Pa., will handle the affairs of the new association.

Investment Casting Institute has awarded cast investments of a whale, mounted on rosewood blocks, to Irving B. Hexter, president of Industrial Publishing Corp., and Robert R. Miller, president of Precision Metalsmiths, Inc. for the "whale of a job" each man did for the ICI.

American Die Casting Institute, Inc. has elected Clifford L. Anthony, Hoover Co., vice president. He will complete the term of C. J. Sheehan, Aluminum Co. of America, who is now president.

Drop Forging Assn. has elected the following directors: Victor J. Taylor, American Brake Shoe Co.; Harold F. Wood, Wyman-Gordon Co.; Barney C. Cox, Melling Forge Co.; Earl M. Tilton, Columbus, Ohio; James H. Greene, Brewer-Titchener Corp.; and George G. Wilcox, Storms Drop Forging Co.

Lead Industries Assn. has elected two new directors: William P. Wilke, Hammond Lead Products, Inc., and Reuben Viener, Hyman Viener & Sons.

Cleveland Engineering Society will start construction of the Cleveland Engineering and Scientific Center although still $650,000 short of its $1,525,000 fund raising goal.

Commercial Chemical Development Assn. has elected the following officers: president—L. E. Johnson, International Nickel Co.; treasurer—W. J. Riley, Food Machinery and Chemical Corp.; executive secretary—G. A. Harrington, Amoco Chemicals Corp. Directors are: W. M. Barnes, Southwest Research Institute and W. A. Woodcock, Union Carbide Chemicals Co.

(News of Meetings on p 268)

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P&H Welding Positioners often cut costs up to 43% by making weldment handling easier.

They raise, rotate, and tilt weldments up to 100,000 pounds, completely freeing operators from the time-consuming, hazardous job of repositioning weldments on the floor.

RESULT: Increased production, less operator fatigue, metal flows more readily, pools more evenly to produce cleaner, stronger welds — because all welding is done in the natural *downhand* position.

For more information about how these useful machines can save you money, write to Department 305G, Harnischfeger Corp., Milwaukee 46, Wis.

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For more information, turn to Reader Service card, circle No. 386

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injection molded
tiny plastic parts
GRIES
GRIES REPRODUCER CORP.
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zinc
die
castings
EXCLUSIVELY

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Small zinc alloy die castings exclusively
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GRC exclusive patented techniques guarantee precise tolerances and uniform quality . . . offer broad design flexibility. GRC saves, too, by doing it in one high-speed operation . . . no trimming, no assembly, no scrap loss.

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Plastic 1¼", .03 oz.
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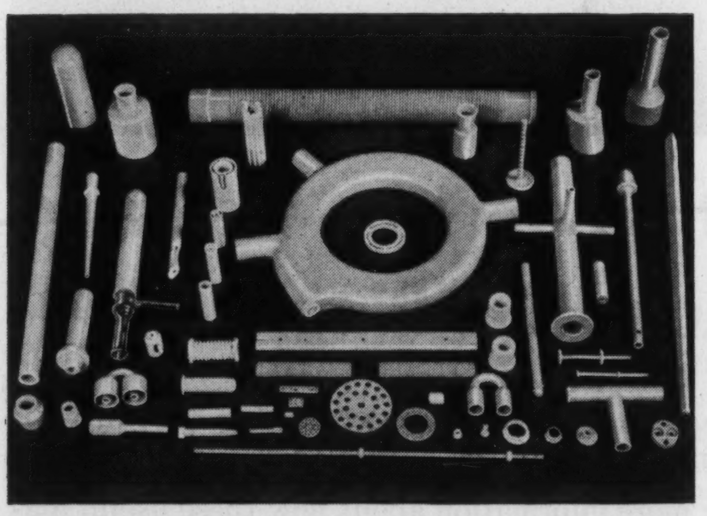

● Got a heat, abrasion or corrosion problem connected with your application? Try ceramics! Instrument manufacturers, scientists, physicists, research workers and specialized producers are applying McDanel Industrial Ceramics to a wide variety of difficult applications with success. Our trained ceramists will work with you to develop design, special dies, specially balanced bodies and mixes . . . even new processes to suit your particular need. Try ceramics! Write today!

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News OF INDUSTRY

Meetings

SOCIETY OF AUTOMOTIVE ENGINEERS, tractor meeting & production forum. Milwaukee, Wis. Sept 9-12.

AMERICAN DIE CASTING INSTITUTE, annual meeting. Chicago. Sept 17-20.

METAL POWDER ASSN., fall meeting. Pocono, Pa. Sept 20-21.

STEEL FOUNDERS' SOCIETY OF AMERICA, fall meeting. Hot Springs, Va. Sept 23-24.

STANDARDS ENGINEERS SOCIETY, sixth annual meeting. New York City. Sept 23-25.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, fall meeting. Hartford, Conn. Sept 23-25.

SIXTH ANNUAL INDUSTRIAL ELECTRONICS SYMPOSIUM. Chicago. Sept 24-25.

NATIONAL SCREW MACHINE PRODUCTS ASSN., fall meeting. Colorado Springs, Sept 29-Oct 3.

SOCIETY OF AUTOMOTIVE ENGINEERS, aeronautic meeting, aircraft production forum and aircraft engineering display. Los Angeles. Oct 1-5.

ELECTROCHEMICAL SOCIETY, INC., fall meeting. Buffalo, N. Y. Oct 6-10.

NATIONAL ELECTRONICS CONFERENCE, 13th annual conference. Chicago. Oct 7-9.

GRAY IRON FOUNDERS' SOCIETY, annual meeting. Chicago. Oct 9-11.

SOCIETY OF THE PLASTICS INDUSTRY, INC., 13th annual New England Section conference. Portsmouth, N. H. Oct 10-11.

PRESSED METAL INSTITUTE, annual meeting. Castle Harbour, Bermuda. Oct 13-17.

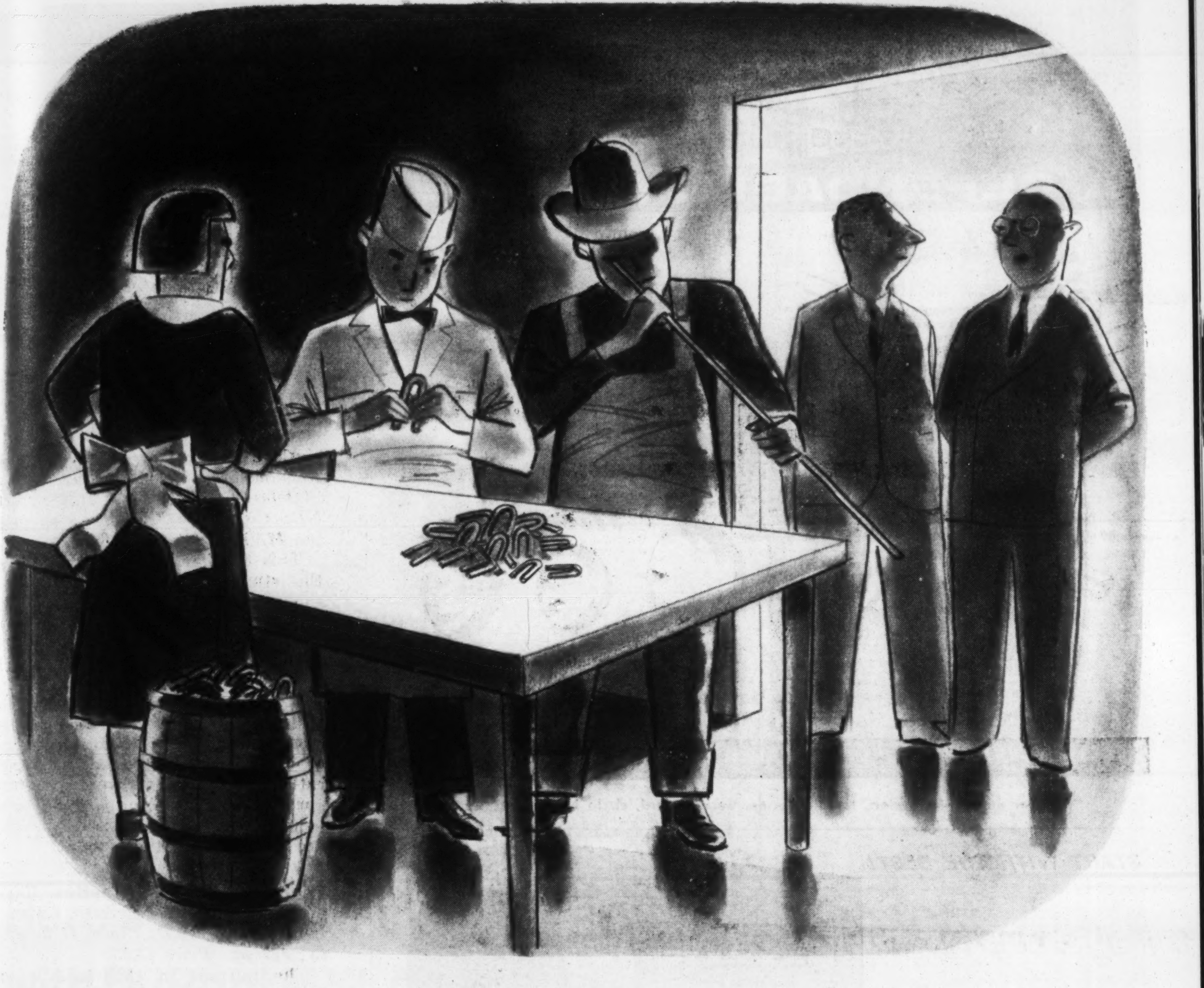
SOCIETY OF THE PLASTICS INDUSTRY, INC., Cellular Plastics Div. conference. New York City. Oct 16.

AMERICAN SOCIETY FOR QUALITY CONTROL, 11th annual conference, New England Sections. Bridgeport, Conn. Oct 16-18.

MAGNESIUM ASSN., annual convention. New York City. Oct 17-18.

NATIONAL ASSN. OF CORROSION ENGINEERS, seventh annual western regional conference. Oct 22-24.

ATOMIC INDUSTRIAL FORUM, fourth annual conference. New York City. Oct 28-30.



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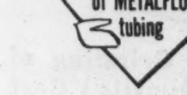
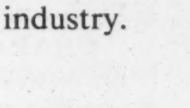

METALFLO

LOCKSEAM

COIL STRIP

SEAMLESS TUBING


TUBULAR PARTS

For more information, turn to Reader Service card, circle No. 567

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BOOKS & REPORTS

Books

Underground Corrosion. *Melvin Romanoff. National Bureau of Standards, Washington, D. C., 1957. NBS Circular 579. Cloth, 8 by 10½ in., 227 pp. Price $3.*

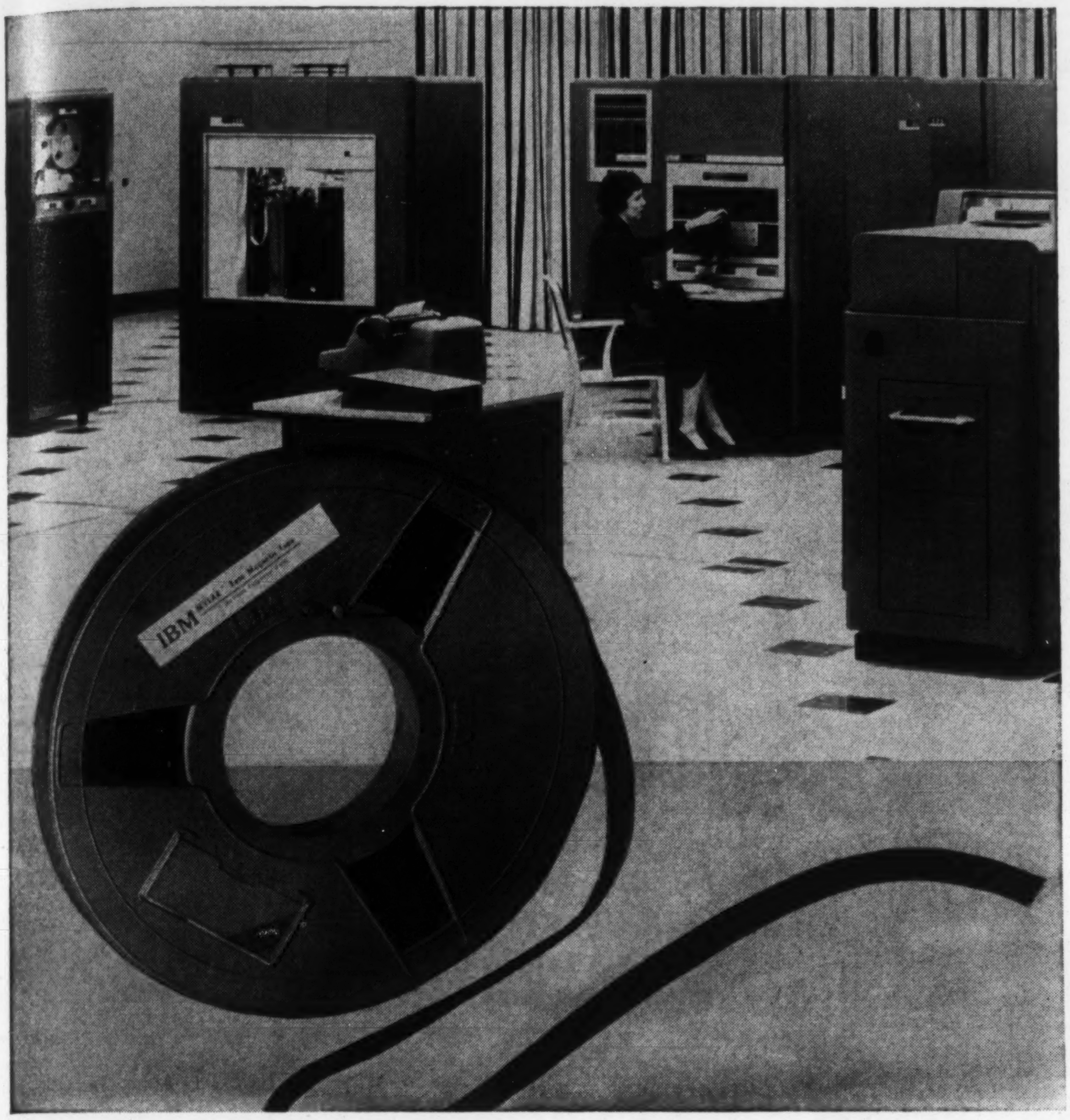
This circular is a final report on the studies of underground corrosion conducted by the Bureau over a period of 45 years. Approximately 37,000 specimens, representing 333 varieties of ferrous, nonferrous and protective materials, were exposed in 128 test locations throughout the United States. During this time the electrical and electrochemical aspects of underground corrosion, including cathodic protection, were continuously studied. Results from both field and laboratory investigations are presented in the circular.

Technical Data on Plastics. *Manufacturing Chemists' Assn., Washington, D. C., 1957. Cloth, 11 by 8½ in., 222 pp. Price $3.25.*

The purpose of this book is to acquaint the reader with the properties that characterize the various commercially available plastics. Each section is devoted to a discussion and presentation of data for plastics having either a basic composition (vinyl chloride polymer and copolymer) or a basic form (thin films). Plastics of like base materials are divided into types, e. g., heat resistant, cold resistant, impact resistant and moisture resistant types. Where further subdivision is necessary several grades are listed under each type. The data presented in the tables are derived from tests made by each contributing manufacturer on his own products.

The Machining and Grinding of Gray and Nodular (Ductile) Cast Irons. *Norman Zlatin and Charles F. Walton. Gray Iron Founders' Society, Inc., Cleveland, 1957. Cloth, 57 pp. Price $3.*

This book is intended primarily for use in the design, engineering and production of cast iron parts. It includes chapters on the selection of tool materials, machining applica-



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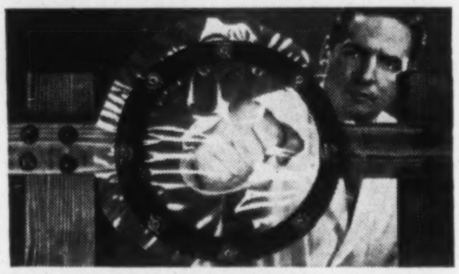

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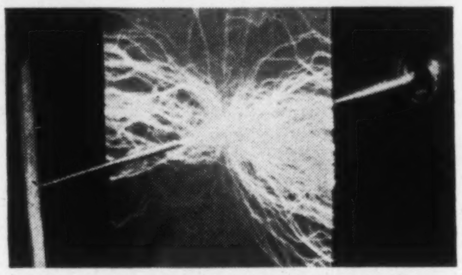

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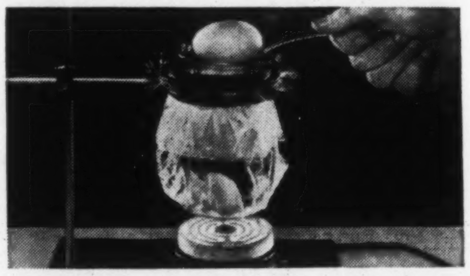

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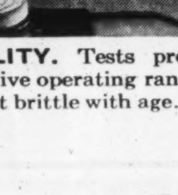

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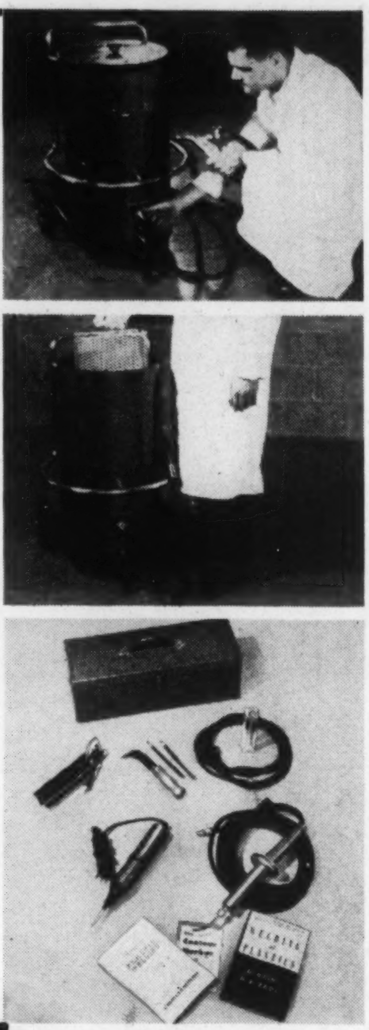

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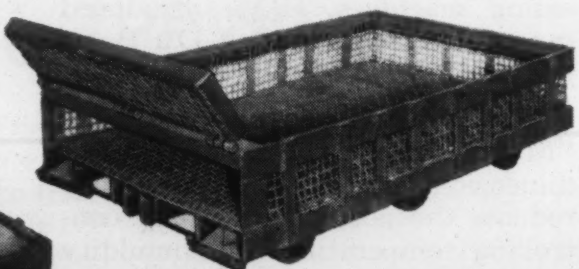

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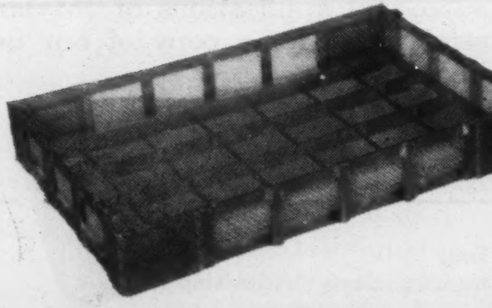

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BOOKS & REPORTS

tions, machining properties of iron castings, economics of machining and general machining recommendations.

Metal Statistics: 1957. *American Metal Market, New York, 1957. Cloth, 4 by 6¼ in., 856 pp. Price $3.50.*

This new edition of *Metal Statistics* marks its 50th year of publication. As in the past it contains a buyers' and sellers' guide and up-to-date information on the production and consumption of such metals as aluminum, antimony, steel, tin, magnesium, lead, copper, titanium, zinc, tungsten, precious metals, lead, nickel, vanadium and cadmium.

Quality Control and Statistical Methods: 2nd Edition. *Edward M. Schrock. Reinhold Publishing Corp., New York. 1957. Cloth, 6 by 9 in., 259 pp. Price $6.75*

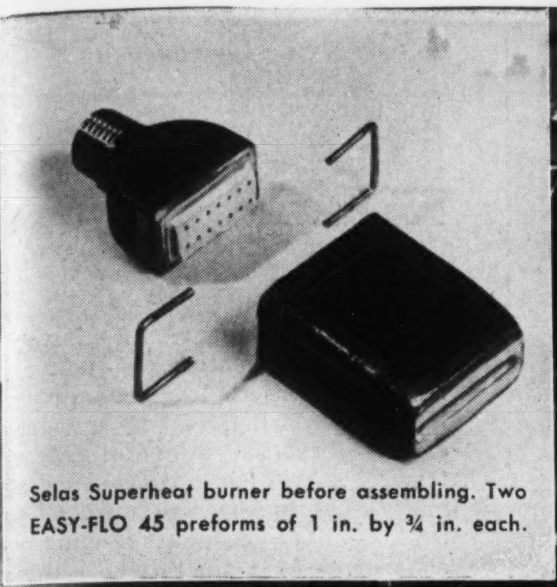
A revised and up-to-date edition of a book that outlines the use of statistical methods in solving industrial quality control problems. This 2nd edition covers the development of the quality control field and the various problems associated with setting up a workable quality control program. The book outlines the use of control charts, explains acceptance sampling, and details the nature and economic objectives of quality.

The Industrial Chemistry, Properties, and Application of Silicones. *Charles E. Reed. American Society for Testing Materials, Philadelphia. 1957. Paper, 6 by 9 in., 52 pp. Price $1.50*

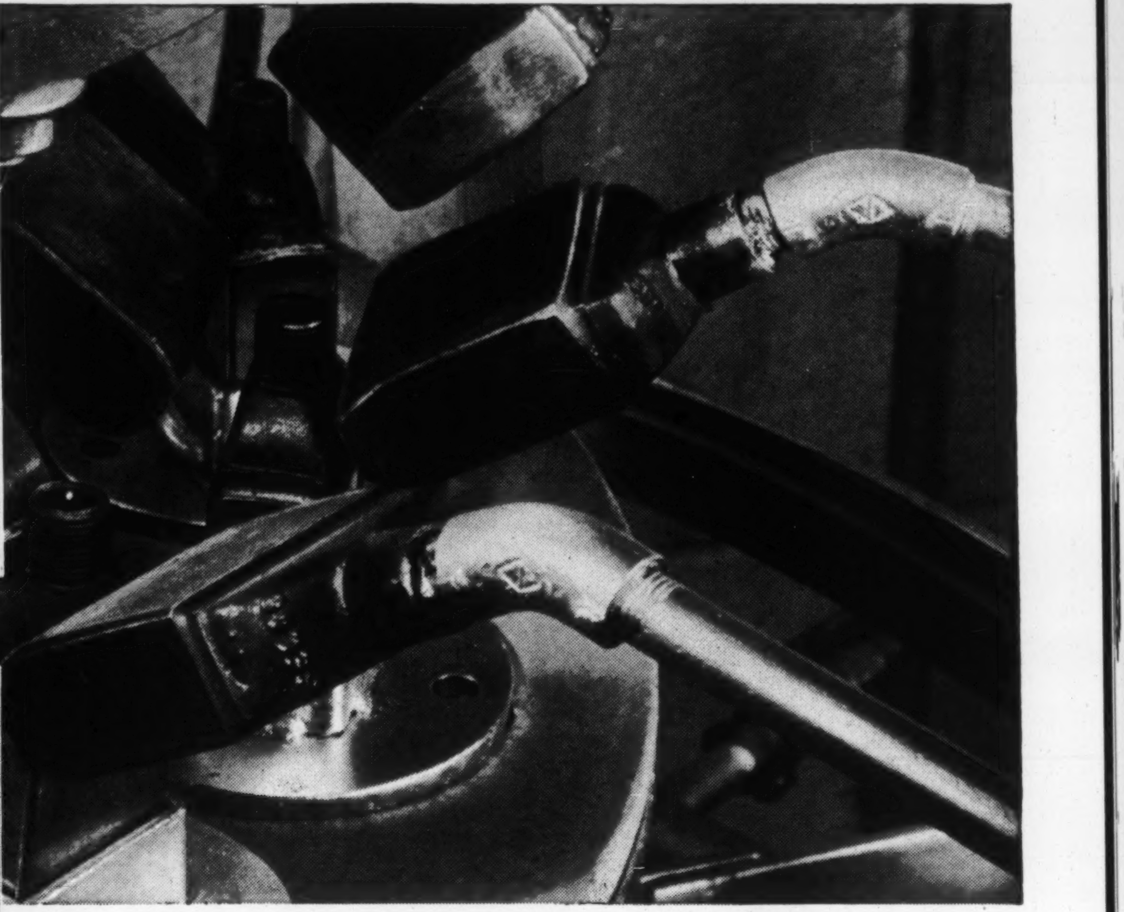
This book, the 13th Edgar Marburg lecture, reviews the basic structural chemistry of the silicones; explains their physical, electrical and mechanical properties; and shows how these properties lead to the use of silicones in protective coatings, electrical equipment, insulated wire and cable, textiles, leather, glass and ceramics. Dr. Reed is general manager of the Silicone Products Dept., General Electric Co.

Symposium on Properties, Tests, and Performance of Electrodeposited Metallic Coatings. *ASTM Special Technical Publication No. 197, American Society for Testing Materials, Philadelphia. 1957. Paper, 6 by 9 in., 129 pp. Price $3.00*

The various papers given in this book discuss: 1) corrosion behavior and protective value of copper-nickel-chromium and nickel-chromium coatings on steel, 2) evaluation of meth-



Selas Superheat burner before assembling. Two EASY-FLO 45 preforms of 1 in. by ¾ in. each.



Operator shown placing assembled burners in Selas rotary gas-air equipment to start 75-second brazing cycle. Large illustration shows burners under heat.

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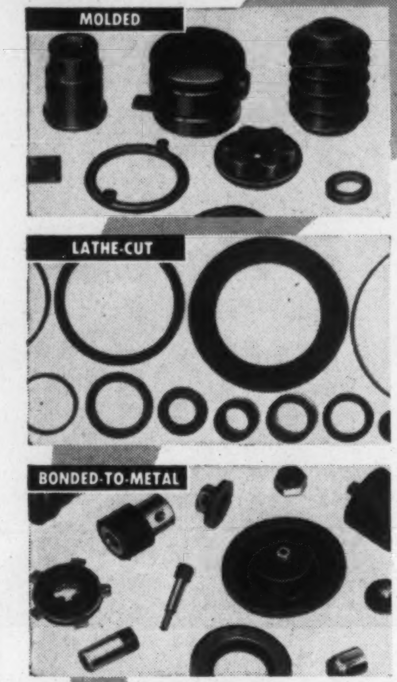

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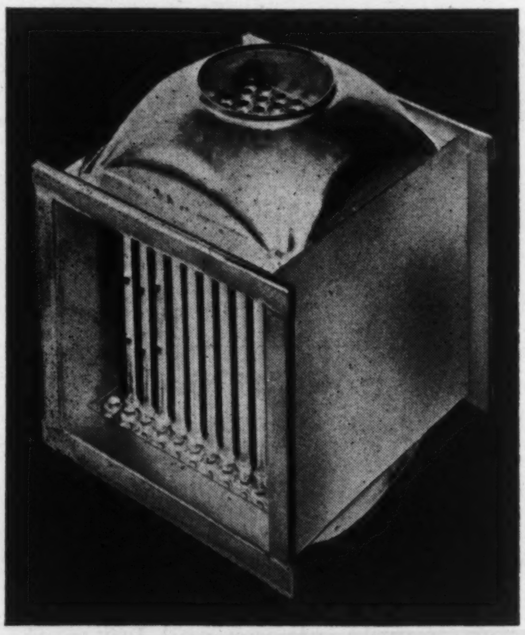

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BOOKS & REPORTS

ods for measuring surface luster of electroplated coatings, 3) recommended practices for cleaning prior to electroplating, 4) a comparison of the corrosion behavior and protective value of electrodeposited zinc and cadmium coatings on steel, 5) evaluation of phosphate coating over electrodeposited zinc, and 6) atmospheric exposure of electroplated lead coatings on steel.

Reports

Airframe design MATERIALS-PROPERTY-DESIGN CRITERIA FOR METALS. PART 4: ELASTIC MODULI, THEIR DETERMINATION AND LIMITS OF APPLICATION. *S. A. Gordon, R. Simon and W. P. Achbach, Battelle Memorial Institute. Oct '56. 23 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price 75¢ (PB 121857)*

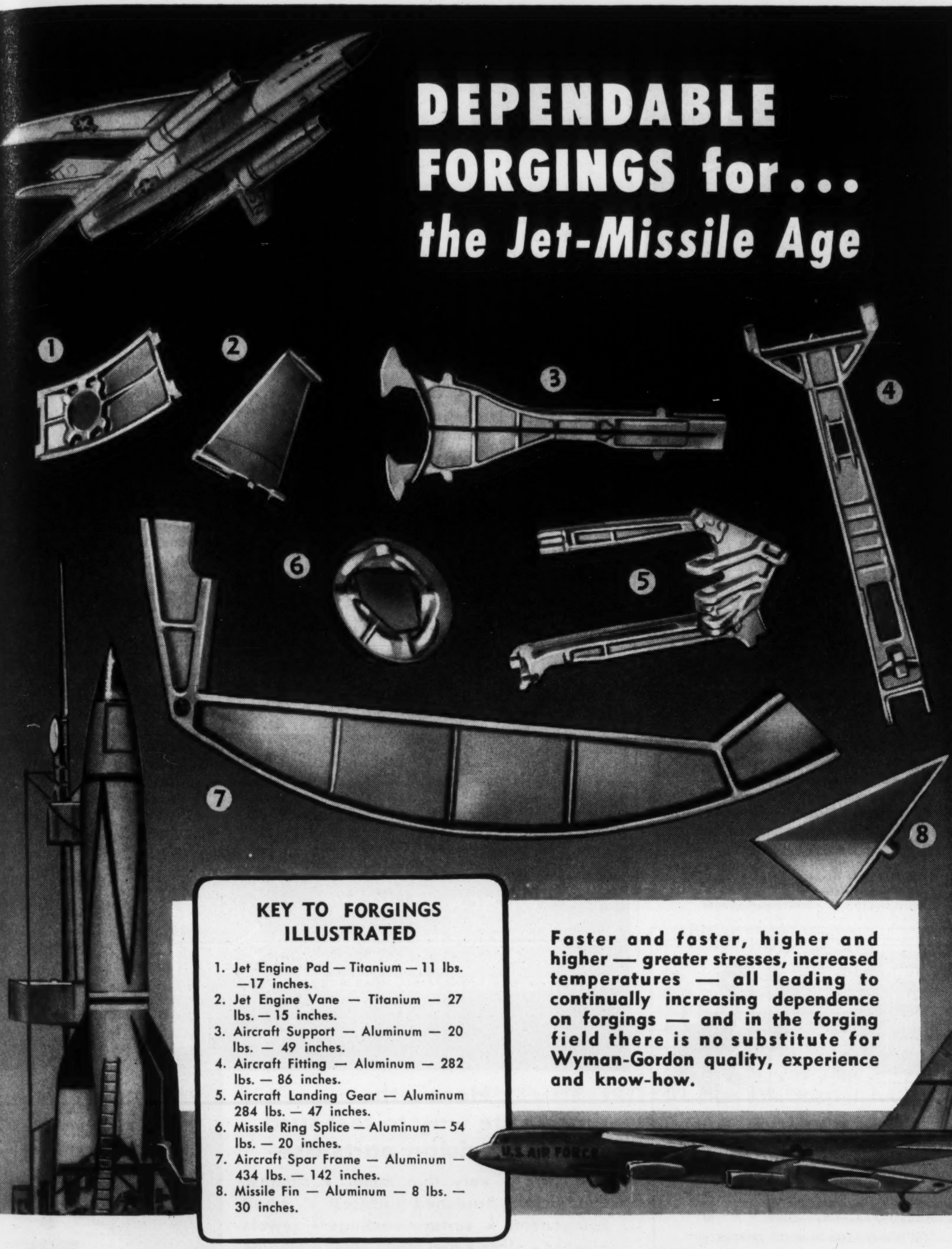
Describes modulus of elasticity at elevated temperatures for several materials as it is derived from the conventional stress-strain curve and from the determination of the velocity of propagation of elastic waves. Tests were performed on a magnesium alloy (AZ-31) and an aluminum alloy (2024-T4). Results are discussed in terms of airframe design.

Welding titanium RESEARCH AND DEVELOPMENT FOR THE WELDING OF TITANIUM AND TITANIUM ALLOYS. FINAL REPORT. *J. J. Chyle and I. Kutuchief, A. O. Smith Corp. Apr '54. 79 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price $2 (PB 111849)*

Describes successful welding of titanium alloys containing chromium, iron, manganese, aluminum and molybdenum by the inert-gas-shielded tungsten arc welding process. The titanium alloys were free of cracks, and no evidence of fissuring was encountered. Tensile strengths of weld metal and joints were equivalent to those of the parent metal.

Copper alloy fracture FRACTURE CHARACTERISTICS OF COPPER-BASE ALLOYS. *N. C. Howells and E. A. Lange, Naval Research Laboratory. Apr '57. 12 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price 50¢ (PB 121933)*

Discusses fracture characteristics of 15 copper-base alloys tested at



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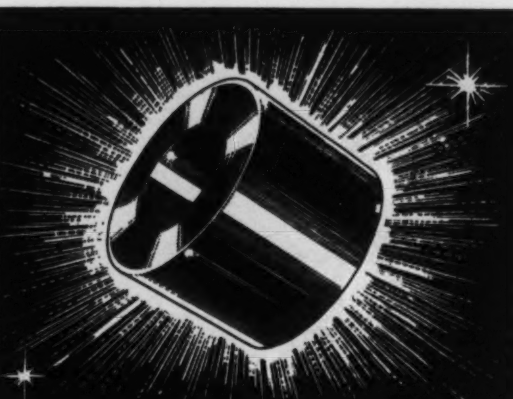

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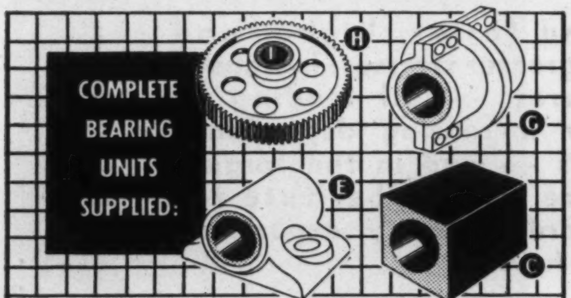

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temperatures ranging from –300 to 210 F. Alloys with low tensile and elongation values were found to fracture in a brittle manner. A high tensile manganese bronze approaches a brittle condition at temperatures below –150 F.

Aluminum fatigue Cumulative Fatigue Damage of Aircraft Structural Materials. Part 2: 2024 and 7075 Aluminum Alloy Additional Data and Evaluation. *A. M. Freudenthal and R. A. Heller, Columbia University. Oct '56. 27 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price 75¢ (PB 121909)*

Fatigue tests conducted on 20 unnotched specimens of 2024 and 7075 aluminum alloys show alloy 2024 to be a more reliable aircraft structural material than alloy 7075.

Cadmium plating Electroplating Baths for Ultra High Strength Steels. Part I—Use of Aliphatic Amino Acids in Cadmium Baths to Reduce Hydrogen Embrittlement. *P. N. Vlannes, S. W. Strauss and B. F. Brown, Naval Research Laboratory. Mar '57. 15 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price 50¢ (PB 121836)*

Electroplating high strength steel in an ammonical bath containing salts of amino acids results in markedly lower hydrogen embrittlement than plating in standard cyanide baths.

Shot peening Protective Shot Peening of Propellers: Part II-Fatigue Tests. *R. F. Broderick, Lessells & Associates, Inc. Aug '55. 56 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price $1.50 (PB 121-464)*

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THE LAST WORD

by H. R. Clauser, *Editor*

Engineering and Philosophy

One of the many pleasant things about a vacation is the opportunity it provides for reading those books you have laid aside because of lack of time for serious reading. In my case two such books were Philipp Frank's "Philosophy of Science," and "Readings in the Philosophy of Science," edited by H. Feigl and M. Brodbeck. And now after reading them, I venture the opinion that they are books everyone interested in the philosophical foundations of science and engineering should read.

I realize that a great majority of working engineers and scientists find little need or time to read philosophy, even on their vacations. And there is no point in kidding ourselves about its importance to our work. A highly competent job of engineering can be done without a knowledge of the basic ideas, the meaning, and the structure of science. As long as we know how to use the facts, the formulas, and the techniques derived from the fundamental principles, we can get along very well and achieve quite satisfactory results.

Learned Ignoramuses

But we also should not kid ourselves about the narrowness of this attitude to our work. We should be aware that when we do not occasionally wonder about things and ask the question "why?" we run the risk of becoming "learned ignoramuses." Ortega y Gasset, in his book, "The Revolt of the Masses," applies this descriptive term to the technical man who wraps himself in his own specialty, mechanically applying the technology he has memorized without thought of its broad meaning and implications.

Actually, there is nothing derogatory meant by the term "learned ignoramus." Today, it is quite acceptable to be one. As a matter of fact, most of our engineering colleges encourage it by simply ignoring the philisophical side of science and engineering.

Why Bother?

It is quite possible that our educators are right. They are training engineers not philosophers. But in spite of its relative unimportance to practical engineering, there are a number of good reasons for interesting yourself in the philosophy of science. For one thing, you are likely to gain more personal satisfaction from your job when you know more about the conceptual scheme upon which all of your daily work is based.

Furthermore, physical theories directly influence human thought and behavior. Newton's concepts of force and mass caused man to revise his common-sense views of rest and motion. And Einstein's relativity concept is slowly changing our traditional ways of thinking about time and space.

Finally, the philosophical side of science is also important because without it there can be no great advances in applied science and engineering. Revolutionary advances are made by questioning fundamental ideas and assumptions, and this is one of the main jobs of the philosophy of science.

As you can see, none of the above reasons are really compelling for the practical man. I'm sure that being well-versed in the philosophy of science will never get you a raise. But you may still be interested in the subject simply because, like many people, you are curious and keep asking "why" about things. If you are one of these individuals and would like to stock up books on the subject for the long winter ahead (or for your vacation), just drop me a letter or a card and I'll send you a reading list that I have found helpful.